PAMPHLET COLL
FAO

28 JAN 1992
FAO

Report of the

FAO Oilseed Mission for Venezuela

9 MAY

March 1949
Baltimore, U. S. A.

FOOD AND AGRICULTURE ORGANIZATION of the UNITED NATIONS

OTHER FAO MISSION REPORTS

Report of the FAO Mission for Greece (March 1947)

In English, Greek, and French (first section only in Spanish). Tables, two maps in color, 42 halftone illustrations, index, 188 pages. $1.50 (Spanish edition $1.00)

Report of the FAO Mission for Poland (May 1948)

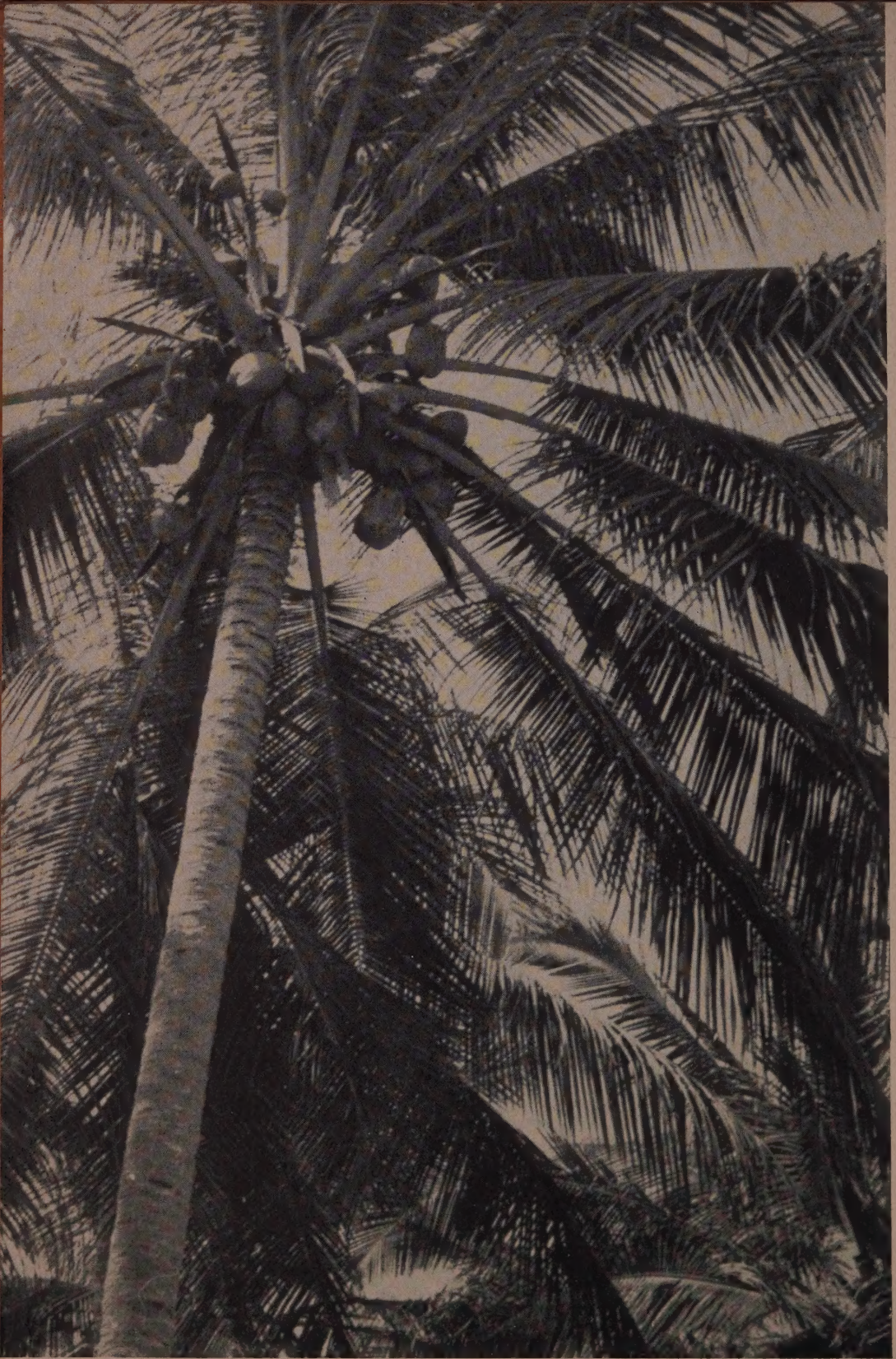
Full report in English only. Tables, two maps, 109 halftone illustrations, index, 159 pages. $2.00

Rapport de la Mission FAO en Pologne (Résumé)

Map, 8 halftone illustrations, 24 pages. 25 cents

Report of the FAO Mission for Siam (September 1948)

In English only. Tables, three maps, 90 halftone illustrations, bibliography, index, 125 pages. $1.50



Crown of a coconut tree, showing fruit and fronds, on a plantation along the Caribbean coast between Puerto Cabello and Tucacas.

Report of the

FAO Oilseed Mission

for Venezuela

March 1949
Washington, U. S. A.

FOOD AND AGRICULTURE ORGANIZATION of the UNITED NATIONS

CONTENTS

LETTER OF TRANSMITTAL vii

I Introduction 1

II Summary of Recommendations 3
- Palms 3
- Annual Oilseed Crops 4
- Processing Facilities 4
- General 5

III The Fat-and-Oil Economy of Venezuela 5
- Current Fat Supply 7
  - Butter 8
  - Lard and Other Animal Fats 9
  - Margarine and Shortening 10
  - Coconut and Other Lauric-Acid Oils 11
  - Cottonseed Oil 13
  - Sesame-Seed Oil 14
  - Groundnut Oil 15
  - Olive Oil and "Unspecified" Oils 16
  - Summary of Edible Fat Supply 16
- Inadequacy of Fat Supply 17

IV Field Work of the Mission 21
- Method of Making Survey 21
  - Preliminary Preparation 21
  - Aerial Reconnaissance 22
  - Aerial Photography 23
  - Ground Survey 23

V Oil-Bearing Palms 25
- Cultivated Palms 25
  - Coconut Palm (*Cocos nucifera*) 25
  - African Oil Palm (*Elaeis guineensis*) 28
  - American Oil Palm (*Corozo oleifera*) 32
- Wild Palms 35
  - *Coroba* (*Scheelea macrolepis* Burret) 37
  - *Yagua* or *Palma Yagua* (*Scheelea humboldtiana* Spruce) 39
  - *Corozo, Yagua, Palma de Vino* (*Scheelea excelsa* Karst. (?)) 39
  - *Coroba* (*Scheelea macrocarpa* Karst.) 41
  - *Seje* (*Jessenia bataua* (Mart.) Burret) 45
  - *Cucurito, Cocorito* (*Maximiliana*) 47
  - *Corozo* (*Acrocomia*) 50
  - *Temiche* (*Manicaria saccifera*) . 53
  - *Macanilla, Tucum, Cumare* (*Astrocaryum*) 54
- Possibilities for Commercial Exploitation 55
- Production Factors 56
- Conclusions 57

VI Cultivated Oilseed Crops 60
- Potential Regions for Oilseed Crop Production 60
- Factors Influencing the Choice of Oilseed Crops 60
- Specific Oilseed Crops 63
  - Sesame (*Sesamum indicum*) 63
  - Sunflower (*Helianthus annuus*) . 65
  - Soybeans (*Glycine max*) 67
  - Groundnuts (*Arachis hypogaea*) 68
  - Castors (*Ricinus communis*) 69
  - Flax (*Linum usitatissimum*) 70
  - Safflower (*Carthamus tinctorius*) 71
  - Other Oilseed Crops 71
- Size of Farm Units 71
- Conclusions 72

VII Processing Facilities 73
- Crude-Oil Mills 73
- Refineries and Shortening Plants .. 77
- Technical Control and Management 79

VIII General Considerations 80
- Collection and Publication of Statistics 80
- Crop-Production Loans 80
- Industrial Fats and Oils 81
- Fish and Marine Oils 81
- Interchangeability of Fats and Oils 81

ACKNOWLEDGMENTS 82

Cable Address: FOODAGRI Telephone EXecutive 7760

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

ORGANISATION DES NATIONS UNIES POUR
L'ALIMENTATION ET L'AGRICULTURE

1201 Connecticut Avenue, Northwest
Washington 6, D. C.

Mr. Norris E. Dodd
Director-General
Food and Agriculture Organization
of the United Nations
Washington, D. C.

Dear Sir:

Pursuant to the request which Sr. Alejandro Orepeza Castillo handed to Sir John Boyd Orr in Caracas, 6 May 1947, to send a FAO Mission to Venezuela to investigate and report upon the edible oil resources of that country, a Mission was appointed consisting of the undersigned technical experts who were charged with conducting the following investigations:

(1) Study of the wild oil-bearing plants of the whole country with a view of their possible industrial utilization;
(2) Recommending cultivation of those oil-bearing plants which in the judgment of the Mission are best suited to the conditions of the country;
(3) Visiting the existing factories in order to make recommendations for improving methods at present in use and equipment available.

The Mission was instructed to submit a report to the Director-General of FAO on the observations made in Venezuela and recommendations for both temporary and long-range solution of such problems as might require urgent action, with special attention to measures that could be put into immediate effect.

Two members and the FAO secretary of the Mission arrived in Venezuela 8 January 1948 and the other member on 5 February 1948. The group spent a total of six man-months in the field work and several additional man-months in the analyses of the results and data obtained while preparing this report.

The work of the Mission comprised a survey of the wild oil-yielding palm areas of Venezuela, including the Orinoco River area from the Amacuro Delta to Puerto Ayacucho, the entire Lake Maracaibo area to the Colombian border, the

area from Barquisimeto to Tucacas and Puerto Cabello, all coastal areas, and the llanos in several localities. The areas were studied by aerial reconnaissance supplemented by aerial photographs. Ground surveys were made by jeep and boat, and collections of the various oil-bearing palms were made and subsequently subjected to chemical analysis and exact botanical identification.

Agronomic studies were made of all annual oil-bearing seeds and of the perennial coconut and African oil palms. Although all annual oilseed crops had been harvested, farms and plantations in the principal areas of production, including the states of Aragua, Carabobo, Cojedes, Portuguesa, Yaracuy, and Falcon, were visited. Farmers and plantation managers were interviewed and their production records examined. Production records of experimental plantings and soil and climatological data of the various government agencies were also examined.

A total of eleven vegetable-oil mills and refineries were visited, including the principal plants located in Caracas, Maracay, Valencia, Puerto Cabello, and Maracaibo.

Technical and managerial personnel were interviewed and the equipment and processes were inspected, for the most part under operating conditions. Statistical data were obtained through the courtesy and co-operation of the various government agencies.

The conclusions and recommendations of the Mission, resulting from a consideration of the personal observations, statistical data, collected information, laboratory analysis, etc., are set forth in the accompanying report, with the hope that they may be of assistance to Venezuela and its people in improving the nutritional, agricultural, and economic status of this forward-looking Latin-American nation.

Yours faithfully,

Dale W. Jenkins

Dale W. Jenkins,

Carl E. Claassen

Carl E. Claassen,

Klare S. Markley

Klare S. Markley, Chief

26 July 1948

I Introduction

AS INDICATED in the letter of transmittal, the FAO Oilseed Mission for Venezuela was organized at the request of the Venezuelan Government, which acted through the Venezuelan Development Corporation *(Corporación Venezolana de Fomento)*, to investigate the vegetable-oil resources of Venezuela. The specific objectives of this Mission are given in the letter of transmittal.

Following a survey by FAO of available personnel having the requisite training and experience for making such a survey, three specialists were selected to form a Mission: a chemist and chemical engineer specialized in fats, oils, and oilseed technology, a plant ecologist specialized in Latin-American palm resources, and an agronomist specialized in oilseed breeding and crop production.

Dr. K. S. Markley, Head of the Oil, Fat and Protein Division, Southern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, New Orleans, Louisiana, was selected to head the Mission. Dr. Markley's previous experience included more than 20 years' research and development work in the field of oils, fats, and waxes, two surveys of European fat and oil industries in 1936 and 1942, and authorship of more than 60 scientific and technical articles and two books on fats and oils.

Dr. Dale W. Jenkins, Specialist in Insect and Plant Ecology, U. S. Army Chemical Center, Edgewood, Maryland, was chosen as the palm specialist of the Mission. Dr. Jenkins previously had made palm and rubber surveys in Central and South America, the West Indies, and Mexico, and is the author of 25 scientific and technical publications, including treatises on the palms of Central America and Mexico, the African oil palm in the Western Hemisphere, and the use of the airplane in vegetation surveys.

Carl E. Claassen, Research Agronomist, Chemurgy Project, the University of Nebraska, Lincoln, Nebraska, U. S. A., was the Mission's agronomist. Mr. Claassen has spent six years in breeding and production of oilseed crops, including sesame, safflower, sunflower, castor, flax, perilla, and rape, at the Nebraska Agriculture Experiment Station and has published several reports on flaxseed and safflower.

Jorge Succar Rahmé, former technical officer, Wood Utilization Section, Forestry Division, Food and Agriculture Organization of the United Nations, Washington, D. C., accompanied the Mission as secretary and interpreter.

In addition to the field members of the Mission, FAO engaged for the Venezuelan Development Corporation the services of Dr. Miriam L. Bomhard, forest ecologist, Forest Service, U. S. Department of Agriculture, Washington, D. C., to make exact botanic identification of all palm material collected by the Mission and shipped to Washington for that purpose. Dr. Bomhard has published on various palm subjects, dealing especially with palm taxonomy and economic values.

Arrangements were made by Dr. Markley before leaving the United States to have Dr. N. G. Nhavi, Department of Industries, Government of Bombay, Bombay, India, make chemical analyses of all samples of palm fruits shipped to the Southern Regional Research Laboratory, New Orleans, Louisiana, U. S. A. These analyses were made by Dr. Nhavi under the direction of F. G. Dollear, Acting Head of the Oil, Fat and Protein Division.

Dr. Markley, Dr. Jenkins, and Mr. Succar arrived in Venezuela on 8 January 1948. On arrival at La Guaira the Mission members were met by Dr. Eric Manelski, Oilseed Branch *(Departamento de Oleaginosas)*, Venezuelan Development Corporation, who acted as liaison officer for the Mission during its stay in Venezuela.

Before beginning its field work, the Mission met with a group of Venezuelan officials consisting of Ricardo Montilla, Minister of Agriculture and Animal Husbandry; Alejandro Oropeza Castillo, President of the Venezuelan Development Corporation; Andrés Germán Otero, Director of the Corporation; Dr. Ricardo de Sola, Vice-Chief, Technical Branch; Dr. Eric Manelski, Oilseed Branch; Prof. Francisco Tamayo, Experimental Institute of Agriculture and Zootechnology *(Instituto Experimental de Agricultura y Zootecnia)*; and Dr. D. G. Langham, Genetics Branch, Ministry of Agriculture and Animal Husbandry *(Departamento de Genética, Ministerio de Agricultura y Cría)*. This group is in Figure 1.

The following Venezuelan officials were designated to co-operate with the Mission:

Professor Tamayo and Dr. Langham, Ministry of Agriculture and Animal Husbandry; Dr. Manelski and Juan Zambrano Perozo, Oilseed Branch, Venezuelan Development Corporation. One or more of these individuals as well as other Venezuelans accompanied the Mission on a number of field trips and assisted in carrying out the objectives of the Mission.

In addition to the field work, it was necessary to acquire an understanding of the existing fat-and-oil economy of Venezuela. Without such an understanding it would be impossible, or at best very difficult, to make rational recommendations. Chapter III of this report consists of the compilation and analysis of all available statistical data bearing on the subject.

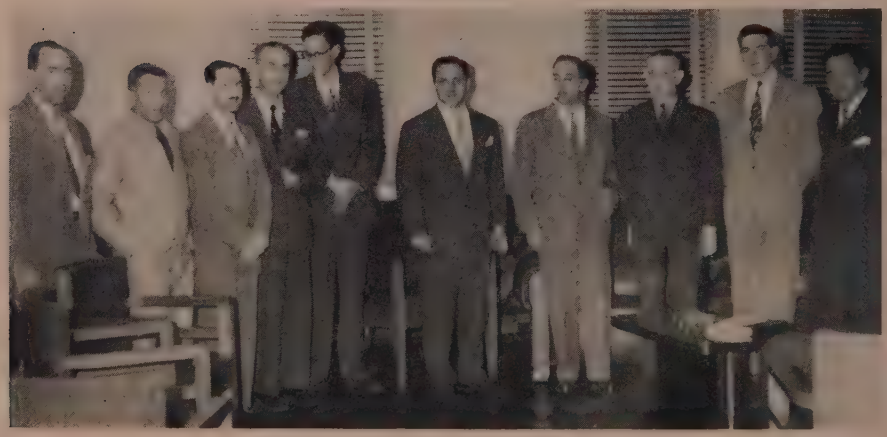


Figure 1. Meeting of the FAO Mission with Venezuelan officials. Left to right, Dr. D. G. Langham, Dr. Eric Manelski, Dr. Ricardo de Sola, Prof. Francisco Tomayo, Andrés Germán Otero, Jorge Succar Rahme, Alejandro Oropeza, Dr. K. S. Markley, Dr. Dale W. Jenkins, and Ricardo Montilla.

II Summary of Recommendations

EACH CHAPTER of the Mission's report contains general discussions and conclusions, general and specific recommendations. The more important recommendations are summarized here. In considering these recommendations, reference should be made to other parts of the report, where problems and recommendations are considered in more detail.

In Chapter III it is indicated that the average annual "visible" supply of edible fats and oils in Venezuela is 13,000 metric tons, or about 9 grams per capita per day, compared with a total "visible and invisible" fat consumption of 125 and 124 grams by the populations of the United States and England. This per-capita consumption of "visible" fats is one of the lowest in the world and is a serious menace to the health and productivity of the people of Venezuela.

An enormous increase in the production of oilseed crops in Venezuela, or a marked increase in imports of oils or oilseeds will be required to overcome this deficit.

Even the modest plans of Báez and Bengoa to raise the per-capita consumption of "visible" fats to 36 grams a day will require a fourfold increase in the present fat supply. To provide the war-emergency minimum recommended by the Committee on Foods of the National Research Council (U. S. A.) would require a 5½-fold increase.

This problem is not only serious; it is difficult to solve quickly under existing conditions. However, the following recommendations are offered for the consideration of all Venezuelans and government officials.

Palms

a. Increased plantings of the coconut palm *(Cocos nucifera)* should be made in suitable coastal and inland areas.

b. The African oil palm *(Elaeis guineensis)* should be planted on a large scale in Venezuela. Scientific research and assistance should be provided by the Government.

c. Experimental plantings of the American oil palm *(Corozo oleifera)* should be begun immediately for comparison with the African oil palm.

d. No large-scale commercial exploitation of wild oil palms should now be attempted or financed.

e. Carefully supervised small-scale exploitation of wild oil palms in the Palma Sola and Encontrados areas might be undertaken to serve as a foundation for possible future programs.

f. Surveys and investigations of wild oil palms should be continued. This should include further studies on the numbers and yield of palms, botanic collections, oil analyses, and especially detailed surveys of production factors in each area.

g. The Venezuelan Government, or an international agency, should attempt to interest responsible industrial machinery manufacturers in designing and constructing an efficient palm-nut cracking machine. No investment should be made in private speculative inventions.

Annual Oilseed Crops

a. Sesame production should be expanded immediately in the states of Portuguesa and Guárico.

b. Sesame production practices should be improved by
using maize planters to plant sesame seed,
using maize binders to harvest tall sesame,
threshing from the shock with a small-model combine, and
employing an extension oilseed specialist who understands farm machinery as an adviser to sesame producers.

c. Commercial seed stocks of better varieties of sunflowers, groundnuts (peanuts), and soybeans should be built up as rapidly as possible.

d. Experimental comparative crop studies of sesame, sunflowers, groundnuts, and soybeans should be established at several locations where production is planned.

e. Experimental work should be undertaken or continued on castors, flax, safflower, perilla, and chia, and carried on for a sufficient number of years to determine the feasibility of commercial production.

f. Large-scale mechanized farming must be developed if the present serious fat deficit is to be bettered or overcome quickly.

Processing Facilities

a. Modernization of crude-oil mills, already in progress to some extent, should be continued with special emphasis on the installation of higher-capacity automatic and semiautomatic equipment, including conveying systems, modern storehouses with automatic handling equipment, and other labor-saving devices.

b. Addition of more cookers to the present single-stack cookers, or their replacement by at least four-stack cookers, and installation of cake strippers and trimmers.

c. Improvement of linter-room equipment, with special attention to maintenance of gin saws in first class condition and installation of lint-flue systems.

d. Replacement of obsolete hydraulic presses with modern expeller presses.

e. Further modernization of refineries and finished-product plants, including the installation of continuous refining equipment, replacement of chill rolls with Votators, installation of automatic filling and labeling machines, etc.

f. Installation of equipment for the manufacture of margarine.

g. Consideration of the installation of a hydrogenation plant for the production of various types of hardened fats.

h. Inauguration of more extensive laboratory control of all raw and finished products; consideration of a new laboratory, either privately owned or on an industry-supported basis, for research and development work on fats and oils.

i. Increased employment in the fat-and-oil industry of technically trained engineers and chemists.

General

a. Immediate establishment of a permanent statistical service for the collection and dissemination of data relative to the fat-and-oil economy of Venezuela, including statistics covering all raw materials, crude-oil milling and refinery operations, and finished products.

b. Because of the considerable importance of coconut oil to the Venezuelan fat economy it is especially recommended that an immediate survey or census of the coconut production and copra-processing industries be made.

c. A progressive or step-wise system of farm loans should be instituted, especially with reference to loans on oilseed crops, in place of the present method of making crop loans.

d. A survey of the industrial fat-and-oil economy of Venezuela should be made by qualified Venezuelan personnel, following the general pattern of the survey of the edible fat-and-oil economy.

e. Consideration should be given to the establishment of a fish- or marine-oil industry to produce oil and meal from waste products of the fish-processing industry.

III The Fat-and-Oil Economy of Venezuela

THE IMPORTANCE of fats in the human diet need not be emphasized here. It derives from two factors: fats are a highly concentrated form of energy and their replacement by carbohydrates would result in too great an increase in the weight and volume of foodstuffs to be handled by the gastro-intestinal tract; restricted use of fats in cooking would make it impossible to prepare palatable and tasty dishes.

There is very little basis on which to establish a "requirement" or "recommended allowance" of dietary fats, but most population groups that can afford a free choice of foods tend to include in their diet enough fat to account for about 25 percent of the calories consumed.

As a further illustration, the Committee on Foods of the National Research Council [1] recommended that the minimum fat consumption during the critical fat shortage in the United States during World War II be set at 30.8 kilograms (68 lbs.) of fat annually per individual, of which it was assumed 18.1 kilograms (40 lbs.) could be derived from "visible" sources and 12.7 kilograms (28 lbs.) from "invisible" sources such as eggs, milk, meats, etc. These levels correspond to a total daily fat consumption of about 84.5 grams per capita, or 49.7 grams of "visible" and 34.8 grams of "invisible" fat. Table 1 shows "visible" fats consumed by civilians in the United States of America before and during World War II.

Báez [2] and Bengoa [3] have suggested two dietary fat levels for Venezuela, one of which provides for a total fat consumption of 78 grams and the other of 93 grams per person per day. According to the first plan the "visible" portion of this requirement would be supplied by an annual consumption of 4.9 kilograms of butter and 8.3 kilograms of lard or oil, and, according to the second plan, by 6.1 kilograms of butter and 8.3 kilograms of lard or oil, or a total of 13.2 kilograms under the first plan and 14.4 kilograms under the second plan. The two plans would require a daily per-capita consumption of "visible" fats of 36 and 40 grams, respectively.

[1] Footnote numbers in the text refer throughout to sources listed at the end of each chapter.

TABLE 1.—EDIBLE FATS AND OILS: TOTAL AND PER-CAPITA CIVILIAN CONSUMPTION, UNITED STATES, 1936–1945

Calendar Year	All fats and oils[1]		Butter[2]		Lard[3]		Margarine[4]		Compounds and vegetable cooking fats[5]		Other edible fats and oils[6]	
	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita
	1,000 metric t.	*Kg.*	*1,000 metric t.*	*Kg.*	*1,000 metric t.*	*Kg.*	*1,000 metric t.*	*Kg.*	*1,000 metric t.*	*Kg.*	*1,000 metric t.*	*Kg.*
1936	2,808	21.8	959	7.4	654	5.1	146	1.1	717	5.6	332	2.6
1937	2,817	21.7	961	7.4	616	4.8	148	1.1	721	5.6	371	2.8
1938	2,851	21.8	974	7.4	651	5.0	142	1.1	680	5.2	404	3.1
1939	2,959	22.5	1,033	7.9	754	5.7	110	0.8	633	4.8	429	3.3
1940	3,010	22.7	1,018	7.7	887	6.7	116	0.9	538	4.0	452	3.4
[7]1941	3,056	23.0	955	7.2	849	6.4	133	1.0	624	4.7	495	3.7
[7]1942	2,877	21.7	939	7.1	816	6.2	134	1.0	532	4.0	456	3.4
[7]1943	2,677	20.6	687	5.3	857	6.6	186	1.4	576	4.4	371	2.9
[7]1944	2,619	20.3	700	5.4	808	6.3	184	1.4	539	4.2	388	3.0
[7,8]1945	2,483	19.1	643	5.0	706	5.4	192	1.5	588	4.5	354	2.7

Source: Bureau of Agricultural Economics, U. S. Department of Agriculture. *Agricultural Statistics, 1946.* Table 202. Converted to metric measurements by FAO.

[1] Butter is included on an actual weight basis, all other fats and oils on fat-content basis.

[2] Includes farm and factory production but excludes butter going into margarine production. Actual weight basis.

[3] Includes rendered pork fat. Lard going into production of nonfood products is excluded.

[4] Fat content of materials used.

[5] Included with "Other edible fats and oils" before 1931.

[6] Fat-content basis. This category includes compounds and vegetable cooking fats for 1929 and 1930. Beginning with 1931, it includes only fats and oils used in cooking and salad oils, in salad dressing, mayonnaise, in bakery products, and in minor uses such as fish canning.

[7] The total apparent civilian consumption for the years 1941-1945 was obtained by subtracting ending stocks, U. S. Department of Agriculture takings, other exports, and military takings from the total supply. The per-capita civilian consumption for each year was obtained by dividing the total apparent civilian consumption by the total population adjusted for underenumeration of children under 5 years of age, less 85 percent of the military forces.

[8] Preliminary.

TABLE 2.—PER-CAPITA CONSUMPTION OF FATS

Country	Period	Per-capita fat consumption		Corresponding calculated requirements for 4,500,000 people
		(G./day)	*(Kg./yr.)*	*(Metric tons/year)*
U.S.A. Civilian	Prewar	[1]125	45.6	205,200
U.S.A. Civilian	World War II[2]	[1]85	31.0	139,500
U.S.A. Military	World War II	[1]193	70.4	316,800
Great Britain	Before 1930	[1]106	38.7	174,150
Great Britain	1934	[1]124	45.2	203,400
Germany	Prewar	[1]60	21.9	98,550
Germany	1939	[3]40	14.6	65,700
Venezuela	Báez-Bengoa plan	[1]78	28.5	128,250
Venezuela	Báez-Bengoa plan	[1]93	33.9	152,550
Venezuela	Báez-Bengoa plan	[3]36	13.2	59,400
Venezuela	Báez-Bengoa plan	[3]40	14.4	64,800

[1] Total "visible" and "invisible" consumption; approximately 40-50 percent of total supply should be in "visible" fats.

[2] Minimum requirements recommended by the Committee on Foods, National Research Council, Washington, U. S. A.

[3] Consumption of "visible" fat.

These data on the per-capita consumption of fats are collected in Table 2. From them the requirements can be calculated for any nation with a known population. Table 2 does not include the many other fat requirements of a nation, some of which are quite large. Beside edible uses, fats and oils are used in the production of soaps and cosmetics, candles, paints, varnishes, enamels, greases, putty, caulking and sealing compounds, pharmaceuticals, etc.

According to the Seventh National Census of Venezuela, taken 7 December 1941, the total population of the country was 3,850,771. Of this total, as shown in Table 3, 24.6 percent lived in cities and towns of 5,000 and over, while the remaining 75.4 percent lived in rural communities of less than 5,000. It is generally assumed that the present population is, in round numbers, 4.5 million inhabitants. Since the 1941 census there has been some migration from rural to urban areas, which has necessarily altered the population ratios in this table.

The amount of fat needed for a population of 4.5 million has been calculated for the different levels of consumption and the results are included in Table 2. It is now in order to determine to what extent these consumption levels have been attained in Venezuela during the past few years.

Considering the climate, the energy requirement per person, especially in industry and agriculture, and other factors affecting the fat requirements of the population, the optimum requirement of the average Venezuelan should not be greatly different from that of the average resident of the United States (125 grams per day), except possibly in its most northerly sections during the midwinter, when the calorie requirements may be slightly higher, and in the coastal lowlands of Venezuela, where the calorie requirements may be somewhat less than average.

Table 3.—Distribution of the Population of Venezuela according to the Census of 1941[3]

	Inhabitants	*Percent*	
Cities of more than 20,000	628,496	16.3	16.3
Cities of 10,000 to 19,999	184,097	4.8	8.3
Towns of 5,000 to 9,999	135,147	3.5	
Rural communities less than 5,000	555,982	14.5	75.4
Scattered rural	2,347,049	60.9	

[3] Refers to literature cited at end of chapter.

Current Fat Supply

It is much easier to estimate an optimum consumption of fats for a nation than to determine the degree to which the estimate is realized. This is particularly true of a country like Venezuela, which does not have available in readily accessible form essential statistical data relative to its fat economy. An effort has been made to determine as accurately as possible the current "visible" consumption of fats in the average Venezuelan diet by using limited data from a variety of widely scattered sources of different degrees of reliability.

Man's so-called "visible" supply of fats comes from two natural sources, animals and oil-bearing seeds or nuts. The end-product may be obtained through factory processes or by household methods applied in the home or on the farm. The so-called "invisible" fats are those consumed in the form of meat, milk, cheese, eggs, cereal grains, fruits, nuts, vegetables, and other dietary items. The gross composition of many of these products is well known and if the average per-capita consumption of each item is known for any part of the population it is possible to calculate the average per-capita intake of fat from these sources.

In general, not many quantitative data are available on fat consumption by the various income groups of the Venezuelan population. A 1940 article in *El Agricultor Venezolano*[4] (The Venezuelan Farmer) stated that, according to data supplied by the Ministry of Development *(Ministerio de Fomento)*, the annual consumption of edible fats and oils in Venezuela for 1938 was 7,000 metric tons, of which 3,665 metric tons was domestically produced. The estimated population was approximately 3.5 million.

According to data compiled by Kifer,[5] edible-fat and -oil consumption in Venezuela in 1946 was 8,300 metric tons, of which 2,300 metric tons was domestically produced and the remainder imported. The population was estimated to be 4.3 million.

There are a few careful studies of the dietary habits of Venezuelans, as for example that of Bengoa,[3] who made a detailed investigation of the diet of rural inhabitants. He found the average diet to correspond approximately to that shown in Table 4. This diet, which probably is fairly representative of a considerable portion of the rural population, is high in carbohydrates,

TABLE 4.—AVERAGE DIET OF RURAL VENEZUELANS[3]

Dietary item	Grams per person per day
Cornbread (*arepa*)	300–600
Beans	76–100
Plantains (*plátanos*)	100–200
Brown sugar (*papelón*)	100–200
Rice	25–50
Soup paste (*pasta para sopa*)	15–30
Meat	50–100
Tubers (*tubérculos*)	100–200

[3] Refers to literature cited at end of chapter.

moderate in proteins, and low in fats. Milk, eggs, butter, garden vegetables, and fresh fruits are almost entirely lacking. According to this author, the total protein intake is 80 to 100 grams, 80 percent of which is of vegetable origin. He states that the quantity of fats is exceptionally low. Aside from the lard used for cooking, in the average rural diet foods contain scarcely any fats, and the total consumption is approximately 40 to 50 grams per person per day. Presumably, Bengoa includes both "visible" and "invisible" fats in this figure, since it is higher than one of his proposed plans for "visible" consumption and considerably lower than his suggested figure for total consumption.

In a survey of the food consumption of several rural towns and surrounding agricultural areas, including the *llanos*, mountain sections, and the coast, Bengoa found the "visible" consumption of fats during the limited period of the survey varied from 17 to 31 grams per person per day for lard and vegetable fats and from 2 to 8 grams per person per day for butter—a total of 19 to 40 grams.

It is probable that the diet of the urban population is somewhat superior in fat supply from the standpoint of both "visible" and "invisible" fat intake. However, the rather high carbohydrate consumption of all income groups in Venezuela precludes a correspondingly high "invisible" fat consumption because, in general, those foods which are high in carbohydrates are low in fats.

In the absence of comprehensive data for computing the "invisible" Venezuelan fat supply, the following discussion is confined to a study of the adequacy of the "visible" supply.

TABLE 5.—BUTTER, DOMESTIC PRODUCTION AND IMPORTS, 1938–1946[3]

Period	Domestic production	Imports	Total
	(*Kilograms*)		
1938	299,104	474,375	773,479
1939	319,353	1,329,499	1,648,852
1940	748,716	496,604	1,245,320
1941	963,049	38,846	1,001,895
1942	1,324,209	2,129	1,326,338
1943	1,668,230	134	1,668,364
1944	1,542,327	114	1,542,441
1945	1,761,578	180,797	1,942,375
1946	1,662,562	253,404	1,915,966
1938–46 av.	1,143,236	308,434	1,451,670

[1] Data from Ministry of Development: *Estadística Mercantil y Marítima*, and *Anuario Estadístico de Venezuela*.

Butter

A 1945 report[6] by the United States Tariff Commission states, "No data are available to show the number of dairy farms in Venezuela, the size of the farms, the number of cattle per herd, or total production of milk. The demand for dairy products, however, far exceeds the domestic supply, which must be supplemented by imports. More milk and milk products are greatly needed in the Venezuelan diet, particularly by low-income groups. The high prices of dairy products, however, make them almost prohibitive to many people."

The report continues, "Milk production by the Venezuelan *criolla* cow is small, averaging about 7 pounds [3.2 kilograms] daily.[7] Little cream or butter is consumed in the country . . . .

"Cheese is the most important processed dairy product in Venezuela; about 24 million pounds [10.9 million kilograms], all of which is made on farms, is produced annually for domestic consumption.

"Cheese is made under rather primitive conditions, as a result of which much of the fat content is lost."

The inadequacy of the butter supply and consumption is evident by reference to Table 5, in which data are tabulated on domestic production and importations for the period 1938-46. On an assumed basis of 4 million inhabitants, the average per-capita consumption of dairy butter over the nine-year period amounted to 363 grams a year. The maximum consumption for the highest year (1945) was only 485 grams, compared with a normal consumption (1937-41) in the United States of 7.52 kilograms (16.6 lbs.) per annum. Current consumption also compares very

unfavorably with the 4.9 and 6.1 kilogram levels proposed by Báez and Bengoa. However, the figures in Table 5 do not reflect the undetermined quantities of cow and goat butter made on the farms for local consumption.

High import duties have been imposed on butter and cheese in order to discourage imports and increase domestic production. Table 5 indicates that this device has been partially successful, since domestic production in 1946 was approximately equal to the combined domestic production and imports in 1939.

According to the Ministry of Agriculture and Animal Husbandry, only four dairies are producing butter on a commercial scale: Perijá Creamery, Machiques; Maracaibo Creamery, Encontrados; National Creamery, Maracaibo; and "Alfa" Creamery, Maracaibo, all in the State of Zulia.

"Alfa" Creamery was visited by members of the Mission. Except for hand-packing butter in tins, this plant uses modern machinery for the manufacture and handling of butter and ice cream. Officials of the company said that "Alfa" also operates two other creameries in the state of Zulia, one at Carmelo, Urdaneta District, the other at Encontrados, Colón District. The three plants were said to have a butter capacity of 103 quintals per day (approximately 10,450 lbs. on the basis that the Spanish quintal = 101.4 lbs.) but at the time they were operating at only 40 percent of capacity because of an inadequate milk supply.

A very considerable expansion of butter production is desirable from the consumer's point of view. Such expansion necessarily depends on an improvement and increase in dairy cattle, which in turn depends on increased and cheaper supplies of protein concentrates, especially those derived by processing oilseeds and other oleaginous materials.

Lard and Other Animal Fats

In addition to milk fat another important source of animal fat is the carcasses of slaughtered animals. Rendered hog fat is known as *lard* when of edible quality and otherwise *inedible pork fat* or *grease*. The fat produced from beef cattle and sheep is known as *tallow* and may be of either edible or inedible grade. Other types of animal greases include bone grease, tankage grease, etc. For definitions and descriptions of various fat products from slaughtered animals, see Bailey's *Industrial Oil and Fat Products*.[8]

Lard can be used for culinary purposes as such, mixed with other fats and milk to form oleomargarine, or with other fats to produce compound shortening. Edible tallow is generally not sold as such for household use, but is used in the manufacture of oleomargarine and compound shortening.

Although there is a considerable slaughter of livestock in Venezuela, as indicated by Table 6, commercial rendering of fat is not practiced on a scale comparable to that followed by the meat packers and grease renderers in the United States. There may be several reasons for this: many animals are slaughtered on the farm or locally to supply near-by markets, the cost of collecting and transporting sufficient raw material to a rendering plant may exceed the value

TABLE 6.—SLAUGHTER OF LIVESTOCK, 1939–46[1]

Period	Cattle		Goats		Sheep		Swine	
	Number of head	Total weight	Number of head	Total weight	Number of head	Total weight	Number of head	Total weight
		Kilograms		*Kilograms*		*Kilograms*		*Kilograms*
1939	285,415	43,534,397	59,584	731,689	1,704	17,793	180,100	8,468,831
1940	297,698	53,192,647	67,952	598,345	6,718	111,091	202,173	9,722,976
1941	290,847	49,764,527	44,382	543,251	20,561	302,219	235,468	10,356,685
1942	300,368	50,771,550	50,166	638,336	18,157	265,307	266,579	11,562,705
1943	282,333	48,118,837	46,248	576,514	18,685	278,309	257,187	11,047,225
1944	283,517	49,768,515	44,338	585,985	21,464	318,247	222,235	8,034,684
1945	328,425	57,324,112	47,780	625,950	24,679	372,212	382,002	11,727,882
1946	363,479	63,223,657	42,481	601,322	22,841	392,128	338,036	12,671,969
1939–46 av.	304,010	51,962,280	50,366	612,674	16,851	257,163	260,472	10,449,119

[1] Data for 1939-44 from *Agriculture in Venezuela*, American Agriculture Series, Pan American Union, Washington, D. C., 1947, p. 30: for 1945-46 from the Ministry of Development, Caracas.

TABLE 7.—LARD, DOMESTIC PRODUCTION AND IMPORTS[1]

Period	Hogs slaughtered	Lard		
		Produced domestically[2]	Imported	Total
		(*Kilograms*)		
1936–40 av.	202,173	1,000,000	2,504,000	3,504,000
1941	235,468	1,200,000	2,788,872	3,988,872
1942	266,579	1,300,000	1,938,654	3,238,654
1943	257,187	1,300,000	1,854,213	3,154,213
1944	240,175	1,200,000	5,598,744	6,798,744
1945	252,002	1,300,000	3,129,172	4,429,172
1946	311,099	1,500,000	2,750,000	4,250,000
1941–46 av.	260,418	1,300,000	3,009,943	4,309,943

[1] Data supplied by the Division of Agricultural Economics, Economic Investigations Branch, Section of Agricultural Economic Research (*Dirección de Economía Agrícola, División de Investigaciones Económicas, Sección de Estudios Agroeconómicos*).
[2] These figures apparently are estimated.

of the low-grade grease that can be recovered, and the yield of fat per animal is relatively low.

Although fairly complete statistics are available on the number of cattle slaughtered, fewer and less reliable data exist on the production of by-products such as lard, tallow, and grease.

Kifer [5] says, "Because few hogs are marketed in Venezuela, estimates of lard output are difficult. There is no production of commercial lard, as such," and, "No estimates of lard production are available but consumption is estimated to be approximately 7,000 tons annually."

According to data supplied to the Mission, given in Table 7, the estimated consumption of 7,000 tons mentioned by Kifer is considerably too high or else the figures for domestic consumption of lard, given in column 3 of Table 7, are too low.

The average number of hogs slaughtered and lard produced in 1941-46, reported in Table 7, represents a yield of approximately 5 kilograms of lard per animal. United States production of lard varies somewhat, depending on the corn-hog price ratio, but in general it is between 12.7 and 14.5 kilograms (28 and 32 lbs.) per animal.[9]

The low figure calculated on the basis of the 1941-46 data for Venezuela does not necessarily imply a correspondingly low fat production per animal, or inefficient recovery, but rather that many animals were slaughtered with no rendering of fat or no reporting if rendered. Although it is improbable that Venezuelan hogs produce the same quantity of fat as those in the United States it is of interest to calculate the probable yield of fat on this assumption. Using the minimum U. S. production of 12.7 kilograms per animal the average annual slaughter of 260,418 hogs would correspond to a lard yield of almost 3.33 million kilograms, or more than the average imports of 1941-46.

Tallow, presumably beef tallow, is produced domestically and is also imported, principally from Argentina. It is probable that in both cases the product is inedible and is used almost entirely for the manufacture of soap. Data for the production and imports of tallow are given in Table 8 but are not included in the composite table of edible fats later in the report.

The domestic production of tallow, like that of lard, is relatively low in comparison with the number of animals slaughtered.

Unrendered fat is not necessarily lost so far as the diet is concerned since some of it is consumed along with the rest of the edible portions of the carcass. However, it has been pointed out by Eduardo Mendoza [10] that the present number of beef cattle (2,800,000) is inadequate to supply the annual slaughter of 700,000 head needed to provide an adequate diet of meat. The actual slaughter of beef cattle in 1946 was only about half the estimated requirements. It follows that tallow production and "invisible" fat supply from this source was proportionally inadequate.

Margarine and Shortening

Margarine does not appear to be manufactured in Venezuela, probably because of the shortage of fluid milk supply, but vegetable shortening is made on a relatively large scale. The latter is

TABLE 8.—TALLOW, DOMESTIC PRODUCTION AND IMPORTS[1]

Period	Animals slaughtered	Tallow		
		Produced domestically	Imported	Total
		(*Metric tons*)		
1936–40 av.	250,000	1,750	148	1,898
1941	290,847	2,035	294	2,329
1942	300,368	2,102	2,385	4,487
1943	282,333	1,976	682	2,658
1944	308,380	2,158	2,300	4,458
1945	328,425	2,298	1,992	4,290
1946	368,948	2,582	1,378	3,960
1941–46 av.	313,217	2,192	1,505	3,697

[1] Data supplied by the Division of Agricultural Economics, Economic Investigations Branch, Section of Agricultural Economic Research, Caracas.

almost invariably made by blending coconut oil or a mixture of coconut oil and some similar oil such as cohune, tucum, or babassu, with highly hydrogenated vegetable oil (140° F. stearin) imported from the United States, and solidifying the mixture on a lard (chill) roll or in Votators.

Bulk imports of vegetable shortening, reported under tariff classification 212 *(Cerdo Vegetal)*, are relatively small. In 1943, 6,000 kilograms were imported from Argentina. However, total imports for 1941 to 1944, inclusive, amounted to only 6,469 kilograms. Margarine does not appear as a separate import item but it may have been imported under the classification of "edible fats, unspecified," referred to later. According to *Revista Mensual de los Productores de Venezuela* (Monthly Review of Venezuelan Producers, No. 39, p. 71) domestic production of shortening for 1944, 1945, and 10 months of 1946 was 3,393,681 kilograms; 3,593,950 kilograms; and 2,862,550 kilograms, respectively, or a three-year average of 3,476,532 kilograms. (Data are for 34 months extrapolated to three years.)

Coconut and Other Lauric-Acid Oils

Coconut Oil. The fruit or nut of the coconut *(Cocos nucifera)* is the world's foremost source of vegetable oil, as shown in Table 9. It is probably the foremost source of vegetable oil in Venezuela. Also in Venezuela, as in many tropical countries, the coconut palm is of great value [11] for reasons other than its oil.

Coconut oil is obtained by pressing the dried coconut meat, or copra, in hydraulic or continuous screw presses, or by fore-pressing copra and solvent-extracting the press cake. Most of the oilmills in Venezuela process copra exclusively or with other oleaginous materials. Copra used in these mills may be either domestic or imported, or both. Imported copra is principally from the Philippines.

Coconut oil is used as an edible fat and for the manufacture of high-grade soap, especially free-lathering toilet soap. In Venezuela, coconut oil, mixed with highly hydrogenated oils (140° F. stearine) imported from the United States, is used in the domestic manufacture of shortening. The oil is also used directly as cooking fat. In the absence of data on end-uses it is difficult to determine the proportion of this oil consumed as edible fat and that used for industrial purposes.

Domestic soap production and consumption in Venezuela is relatively large: in December

TABLE 9.—AVERAGE ANNUAL PRODUCTION AND NET EXPORT OF THE MAJOR OIL CROPS OF THE WORLD, IN TERMS OF OIL DURING 1934–38[1]

Oil Crop	Production	Net export
	(....*1,000 metric tons*....)	
Coconuts	2,675	1,060
Peanuts (groundnuts)	2,370	681
Flaxseed (linseed)	1,166	644
Palm	745	445
Soybeans	1,791	404
Palm kernel	365	310
Cottonseed	2,009	163
Olive	869	121
Tung	120	78
Sesame	693	68
Rapeseed and mustard seed	1,345	41
Sunflower	589	29
Babassu	25	12

[1] Reproduced from P. L. Hansen and R. L. Mighell, U. S. Department of Agriculture, Technical Bulletin No. 940, November 1947.

1947 a total of 43 factories were engaged in the manufacture of soap.[12] Eight of these factories are in the Federal District *(Distrito Federal)* and 35 in the remainder of Venezuela. The 1947 average monthly production of soap was 494,000 kilograms for the Federal District and 1,004,000 kilograms for the rest of Venezuela. This production is equivalent to a total production of 17,976 metric tons per annum.

The Venezuelan Commission of Inter-American Development [13] reports that in 1944 the soap industry had been for some time supplying the entire domestic demand for laundry soap and more than 70 percent of the toilet soap consumed in Venezuela. Soap production in 1943 was reported to be approximately 12,000 metric tons. Raw materials, however, were inadequate to supply the demand of the soap manufacturers.

The principal fats used in Venezuela in the manufacture of soap are coconut and other lauric-acid oils, tallow and refinery "foots" or soapstock. It may be assumed that practically all of the imports of tallow were consumed by the soap manufacturers but no exact data are available to indicate what proportion of the domestic production and imports of coconut and other lauric-acid oils was consumed in the manufacture of soap.

Despite the very considerable importance of the coconut to Venezuela, systematic data on its production and use are virtually nonexistent. Many large and small plantations are devoted to the production of coconuts and the soap and

shortening industries largely depend on the production and importation of this and other lauric-acid oils or oil-bearing materials. The coconut is also important in the manufacture of shredded coconut, and it is consumed to some extent in the form of coconut water and so-called custard. These latter uses, however, are said to represent less than 5 percent of the total coconut production.

Although no completely reliable data are available, it is variously estimated that Venezuela contains 900,000 to 1,500,000 coconut trees. Assuming an average yield of 60 coconuts per tree per year the estimated number of trees would correspond to a yield of 54 to 90 million coconuts a year. If it is assumed, as it is in some quarters of Venezuela, that five coconuts are equivalent to one kilogram of copra, the calculated production of copra would correspond to 10,800 to 18,000 metric tons. It is probable that the equivalence figure of five coconuts to the kilogram of copra is too low, and it does not correspond to that of other copra-producing areas of the world.

The paucity of data on the production of coconuts and copra extends also to coconut oil. Table 10 contains all of the data that could be obtained from various government agencies and from an intensive search of the literature.

The trade estimates that domestic copra production amounts to 2,000 metric tons a year and that requirements are about ten times as great. It is probable that production is underestimated and requirements exaggerated, but there is no doubt that requirements are several times larger than present domestic production.

When the figures for the production of shortening (3,476 metric tons a year, 1944-46 average) and soap (17,976 metric tons a year, 1947) are considered in the light of the fact that they contain large percentages of coconut oil, the estimated production of copra (2,000 metric tons a year) is apparently considerably underestimated.

Corozo-Kernel Oil. In many South and Central American countries, various quantities of palm kernels are produced which yield oils similar in composition and use to coconut oil. These palm nuts include babassu, cohune, *corozo*, tucum, murumuru, etc. Kernels of these nuts assumed considerable importance during World War II, when supplies of copra from the Philippines and the South Pacific were difficult or impossible to obtain.

Various quantities of these kernels were imported into Venezuela during the war years under the tariff classification 209 D-*Corozo* (See Table 10). The exact identity of the kernels is not known, but it was observed that all but 162 metric tons of the imports from 1941 to 1944, inclusive, originated in Brazil and may have consisted primarily of babassu kernels. Also several mills were crushing babassu kernels at the time they were visited by the Mission. Of the 162 metric tons of "*corozo*" kernels which were not of Brazilian origin, all but 20 tons were of Ecuadorian origin and probably were not babassu.

Although the exact identity of these palm kernels is not known, it is probably safe to assume that they represented various species of *Scheelea*, *Attalea*, and *Corozo oleifera*. Most of these palm

TABLE 10.—COCONUT AND OTHER LAURIC-ACID OILS, PRODUCTION AND IMPORTS[1]

Period	Copra		Coconut oil		*Corozo*	
	Domestic production	Imports	Domestic production	Imports	Imports of kernels	Calculated production of oil[2]
	(*Metric tons*)		(*Kilograms*)		(*Metric tons*)	
1941	.....	2,539	.....	480,000	6,284	3,142
1942	.....	0.4	.....	28,000	3,257	1,628.5
1943	.....	1,574	.....	537,787	363	181.5
1944	.....	1,736.3	.....	477,400	0.5	0.2
1945	.....	31.06	[3]142,976	383,600	0	0
1946	.....	4.66	[3]228,369	1,000	18.8	9.4
1941–46 av.	.....	[4]980.9	[5].....	317,964	1,653.9	826.9

[1] Data from Statistical Division, Ministry of Development.
[2] Outturn of oil assumed to be 50 percent of weight of kernels.
[3] Data from *Revista Mensual de los Productores de Venezuela*, No. 39, p. 71; 1946 data for 10 months only.
[4] Imports of Philippine copra for 1947 amounted to 7,862 metric tons, according to the U. S. Department of Commerce "Industry Report on Fats and Oils," *Ann. Rev. 1947*.
[5] Official estimate of 1941-46 average production of coconut oil is 6,600 metric tons.

kernels are relatively high in oil content (45 to 65 percent), so for purposes of estimating the probable outturn of oil under Venezuelan conditions it has been assumed that the average oil content of the imported *"corozo"* kernels was 55 percent and the average milling efficiency 90 percent, equivalent to a 50-percent yield of oil. The average annual imports for the six-year period 1941-46 of *"corozo"* kernels (Table 10) is therefore equivalent to 826.9 metric tons of oil.

Since *corozo*-kernel and coconut oils are largely interchangeable, it may be assumed that the former oil was used both as an edible fat and in the manufacture of soap, therefore only half of the estimated production, or 413.5 metric tons, can be considered as being consumed in edible channels.

Cottonseed Oil

The amount of cottenseed available for conversion into oil depends upon the local production of lint cotton, since cottonseed is generally not an important item of international commerce. Cottonseed, especially that derived from upland varieties, contains considerable adhering linters. It is bulky and difficult to transport and store and is therefore generally processed close to the area of production.

Cottonseed oil, produced by expression of delintered and decorticated cottonseed, is one of the world's principal sources of edible oil (see Table 9). Until 1943, when cottonseed and soybean oils were nearly equal in volume of production, cottonseed was the principal source of edible oil consumed in the United States.

As is evident from several recent publications on the subject [14, 15, 16], the production of cotton in Venezuela has had a long and varied history since its introduction as an agronomic crop in 1762.

According to an article [17] published in 1946, the production of cotton in Venezuela has not been sufficient to meet the domestic needs of the textile industry. The yield of fiber in Venezuela is quite low compared with that of Egypt, Peru, Argentina, and other cotton-producing countries. This is caused principally by diseases, pests, and poor seed selection.

The Ministry of Agriculture and Animal Husbandry, through the Cotton Commission, created in 1938, has campaigned intensively to expand the cultivation of cotton. The Bank of Agriculture and Livestock *(Banco Agrícola y Pecuario)* has changed its credit policy to supply more aid to the producers of cotton by increasing the amount of credit; it has been demonstrated that small loans do not permit adequate expansion of production to benefit the producer.

According to Lairet,[16] there are no exact data on the production of cotton in Venezuela before 1939, but the production of this commodity has increased steadily from about 1,500,000 kilograms in 1939 to a little more than 3,500,000 kilograms in 1943. According to the estimates made by the Bank of Agriculture and Livestock[17] the yield of seed cotton in 1945 was 10,290,800 kilograms, of which the state of Carabobo produced 36.46 percent, Aragua 27.21 percent, Portuguesa 15.56 percent, and the remaining 20.76 percent was produced in nine other states. It was also reported that this yield of seed cotton produced approximately 3,400,000 kilograms of ginned cotton, a quantity slightly greater than the average yield for the previous five years.

In spite of the general excellence of recent literature on Venezuelan cotton production, little consideration has been given to cottonseed, an important by-product of this crop. None of the articles referred to provides any data on seed production or on the products derived from the seed—linters, oil, cake, and hulls.

Data on production, imports, and use of cottonseed for oil are given in Table 11. Planting stock accounts for the difference in the amount of seed produced and processed. It is probable but not certain that the seed under "Imports" is also planting stock.

On the basis of many years of experience in processing cottonseed in the United States, the proportional yield of products has been calculated [18] as: linters 7.15 percent, hulls 26.0 percent, cake 45.3 percent, crude oil 15.6 percent, loss (principally moisture) 6.0 percent. It is doubtful that these same yields are applicable to Venezuelan conditions because in general the cotton gins and oilmills are less efficient than similar establishments in the United States. Observation by the Mission in Venezuela indicated a higher percentage of linters left on the seed after ginning, very poor delintering operation at the oilmill, poor separation of hulls and kernels, and an abnormally high content of oil in the press cake, often as much as 10 percent compared to 3.5 to 5 percent in the United States.

Some of the oilmills of Venezuela are relatively efficient but others are very inefficient, and it is doubtful whether the average outturn of cottonseed oil for all mills exceeds 13 percent of the

TABLE 11.—COTTONSEED AND COTTONSEED OIL, DOMESTIC PRODUCTION AND IMPORTS[1]

Period	Yield	Production	Imports	Total	Processed for oil	Estimated yield of oil[2]
		(*Metric tons*)				
	(*Kg./ha.*)					
1936–40 av.	578	4,700	58.5	4,758	4,590	596.7
1941	313	4,528	2.7	4,531	4,309	560.2
1942	236	5,032	18.0	5,050	4,708	612.0
1943	225	6,173	91.8	6,265	5,757	748.5
1944	252	5,897	.....	5,897	5,542	720.5
1945	306	6,149	0.6	6,149	5,845	759.8
1946	276	4,898	0.07	4,898	5,699	740.9
1941–46 av.	268	5,446	18.8	5,464	5,310	690.3

[1] Data from the Agricultural Economics Branch, Ministry of Agriculture and Animal Husbandry.
[2] Yield of oil calculated as 13 percent of weight of seed.

weight of seed processed. This percentage has been used in estimating the probable outturn of oil, given in column 7, Table 11.

According to the U. S. Department of Agriculture, the average production of cottonseed in the United States for 1944 was 549 kilograms per hectare (490 lbs. per acre).[19] According to data supplied by the Ministry of Agriculture and Animal Husbandry, the 1936-40 average production of cottonseed in Venezuela was 578 kilograms per hectare, or appreciably higher than the average production in the United States. However, data for 1941-46 indicate an average production of only 268 kilograms per hectare, or less than half of the previous five-year average.

The 1941-46 average yield of cottonseed (268 kg./ha.) is equivalent to a production of only 41.5 kilograms of oil per hectare (37.0 lbs. per acre) on the assumption the outturn of oil averaged 15.6 percent. Comparison of this figure with average yields of various edible oils in the United States —78.5 kilograms per hectare for cottonseed, 190.7 kilograms for soybeans, and 242.2 kilograms for groundnuts—shows that Venezuelan cottonseed is a very poor source of oil.

However, cottonseed oil is a by-product of cotton concerning which the Venezuelan Government has adopted a policy of expansion at least equivalent to domestic needs for fiber. Using the United States ratio of 9 to 5 for cottonseed to lint fiber and 15.6 percent as the content of oil in the seed or 13 percent as the mill outturn of oil, the equivalent production and outturn of oil equivalent to any assumed fiber production can be estimated.

Sesame-Seed Oil

According to Langham and Rodríguez,[20] sesame has been grown commercially in Venezuela since 1912. Until very recently, it was grown principally in the State of Falcón and more especially in the Paraguaná Peninsula. The degree to which sesame production has been concentrated in the past is indicated in Table 12. According to the Bank of Agriculture and Livestock, the 1937 harvest of sesame amounted to 701,666 kilograms, of which 683,880 kilograms or 97.4 percent was produced in the State of Falcón. In 1945, total production amounted to 1,962,000 kilograms, of which 1,885,000 kilograms or 96.1 percent was produced in Falcón. It was stated that sesame constituted 60 percent of the cultivated area of this state.

Because of the importance of sesame in this area, members of the Mission went to Coro, the chief collecting center for sesame produced in the Paraguaná Peninsula and adjacent territory. However, it was learned through interviews with sesame buyers and the agronomist at the Falcón

TABLE 12.—SESAME, PRODUCTION IN 1945 BY STATES[1]

State	Kilograms	Percent
Falcón	1,885,000	96.1
Guárico	35,000	1.8
Trujillo	20,000	1.0
Aragua	12,000	0.6
Lara	10,000	0.5
TOTAL	1,962,000	100.0

[1] *Revista del Banco Agrícola y Pecuario*, No. 1, January 1946.

TABLE 13.—SESAME SEED AND OIL, DOMESTIC PRODUCTION AND IMPORTS[1]

Period	Domestic production	Imports	Total	Processed for oil	Calculated production of oil[2]
	(*Metric tons*)				
1936–40 av.	900	.....	900	982	461.5
1941	1,050	594.2	1,644	1,707	802.3
1942	1,120	75.0	1,195	1,777	553.2
1943	2,920	.....	2,920	2,897	1,361.6
1944	2,708	146.9	2,855	2,851	1,339.9
1945	[3]750	492.0	1,242	1,081	655.0
1946	2,855	.....	2,855	2,522	1,045.4
1941–46 av.	1,900	218.0	2,118	2,039	958.3

[1] Data supplied by the Division of Agricultural Economics, Ministry of Agriculture and Animal Husbandry.
[2] Data for 1945 and 1946 were supplied, other figures calculated on basis of 47 percent outturn of oil.
[3] *Revista del Banco Agrícola y Pecuario*, No. 1, January 1946, page 36, gives sesame production for 1945 as 1,962,000 kg.

State Experimental Farm *(Granja Agrícola del Estado de Falcón)* that the 1948 crop was a complete failure as a result of prolonged drought.

The oil produced from sesame seed is excellent for all culinary purposes and the domestic supply of this seed has been augmented by importations of additional quantities for crushing. Data on domestic production and imports of sesame seed, as well as the calculated production of oil, are given in Table 13.

Sesame seed contains from 50 to 55 percent of oil and under average processing conditions in the United States it yields 47 percent.[21] This figure was used in calculating the outturn of sesame oil shown in column 6, Table 13, except for the years 1945 and 1946, data for which were supplied by the Agricultural Economics Branch *(División de Economía Agrícola)*, Ministry of Agriculture and Animal Husbandry.

The average annual yield of sesame seed in Venezuela has been reported to be 600 kilograms per hectare for the five-year period 1936-40 and 740 kilograms per hectare for the five-year period 1941-45. However, yields as high as 1,000 kilograms to the hectare have been reported. Assuming an average oil content of 50 percent in Venezuelan sesame seed, these yields correspond, respectively, to a production of 300, 370, and 500 kilograms of oil per hectare—the highest per-unit fat production of any present annual oilseed crop in Venezuela. Indeed, if the average figure of 600 kilograms of copra per hectare is correct and the oil content of this material is assumed to be 60 to 65 percent, the oil production per hectare for sesame compares favorably with that of coconut.

Groundnut Oil

Although groundnuts (peanuts), are the second most important oilseed crop in the world and the most important annual oilseed crop (see Table 9), they do not appear to have been very important in Venezuelan agriculture in recent years and have contributed but little to the oil economy of the country. This is surprising in a country having large areas of land which, superficially at least, appear to be well adapted to the production of groundnuts. Although the average yield of this crop for the period 1936-40 is relatively low, 600 kilograms to the hectare, yields of 1,000 kilograms per hectare were reported in 1944 and 1945. These yields are comparable with the best average in the United States and are appreciably higher than the average for the Texas and Georgia-Florida-Alabama areas, which produce most of the groundnuts processed for oil in the United States.

The available data on Venezuelan production and imports of groundnuts are given in Table 14. No imports of groundnut oil are contained in this table. However, the Ministry of Agriculture and Animal Husbandry [22] reported imports of 2,000 metric tons of groundnut oil from Argentina in 1946. It is possible that this item is contained under imports of "edible oils, unspecified," to be discussed later.

Whether the groundnuts included under "imports" are shelled or unshelled is not known, but those for planting, edible purposes, and for oil-milling are probably included. Groundnuts intended for planting are probably unshelled, since they rapidly lose viability after shelling. Those intended for oil-milling are probably shelled,

TABLE 14.—GROUNDNUTS AND GROUNDNUT OIL, DOMESTIC PRODUCTION AND IMPORTS[1]

Period	Domestic production	Imports	Total	Oil produced
	(.....*Metric tons*.....)			*Kg.*
1936–40 av.	20.4	7.2	27.6	....
1941	27.2	3.4	30.6	....
1942	....	2,073.9	....	....
1943	111.2	0.5	111.7	....
1944	45.6	1,994.6	2,040.2	[2]663,457
1945	49.0	2,886.7	2,935.7	[2]1,008,646
1946	64.0	60.5	124.5	[2]327,395
1944–46 av.	52.9	1,647.3	1,700.1	666,499

[1] Data from the Agricultural Economics Branch, Ministry of Agriculture and Animal Husbandry.
[2] Data from the Statistics Division, Ministry of Development.

since they are usually shipped in this form to reduce volume and freight charges.

TABLE 15.—OLIVE OIL AND UNSPECIFIED OILS, [1]IMPORTS

Period	Olive oil	Unspecified edible oil	Unspecified oilseeds	Oil equivalent to unspecified oilseeds[2]
	(*Kilograms*)	(.....*Metric tons*.....)		
1938	1,213,161	.....	.....	.....
1939	1,045,309	.....	.....	.....
1940	904,723	.....	.....	.....
1941	45,472	882	84	31.0
1942	6,861	319	423	156.5
1943	20,716	203	348	128.8
1944	23,167	902.7	[3]912.2	337.5
1945	73,626	772.9	46.8	17.3
1946	14,133	1,828.1	660.3	244.3
1938–46 av.	371,908	[4]817.9	[4]412.4	[4]152.6

[1] Data from the *Anuario Estadistico de Venezuela* (Statistical Yearbook of Venezuela), Statistics Division, Ministry of Development.
[2] Calculated on the assumption of an average 35 percent outturn of oil.
[3] Includes 500.6 metric tons of sunflowerseed.
[4] Average for 1941-46.

Olive Oil and "Unspecified" Oils

Olive oil was at one time an important item in the fat economy of Venezuela, as shown in Table 15. This oil is entirely of foreign origin, principally from the Mediterranean area. Amounts imported between 1938 and 1946 sharply reflect the unsettled conditions in Europe during that period. Olive oil possesses few advantages as a cooking or salad oil over sesame, groundnut, or sunflowerseed oils, all of which can be produced in Venezuela and elsewhere in Latin America. Olive oil will probably become an item of diminishing importance in the Venezuelan fat economy.

Unspecified Oils. Included under classification 5C of Venezuelan imports is a group of oils designated "edible oils, unspecified." It is not clear what oils are included in this group but they probably include the more common oils of commerce in the Western Hemisphere—cottonseed, groundnut, sunflower, soybean, etc. These oils are interchangeable for all practical purposes, differing principally in their keeping quality or resistance to reversion and rancidity. Imports of these unspecified oils are shown in Table 15.

Unspecified Oilseeds. Included in the Venezuelan imports under classification 209C is a group designated as "oilseeds, unspecified." The quantities of oilseeds imported under this item vary considerably from year to year, as shown in Table 15. It is not clear what oilseeds are included in this group since the principal oil-bearing materials, such as sesame, groundnuts, sunflower, copra, *corozo,* linseed, etc., are specifically classified.

In 1944, 500.6 metric tons of sunflowerseed were imported and this is included in Table 15 under unspecified oils. It is not known whether this seed was decorticated or undecorticated; both types are found in commerce in South America. Undecorticated sunflowerseed contains from 22 to 32 percent of oil and decorticated seed from 49 to 54 percent of oil. Since, in general, the identity and amounts of individual oilseeds included in this unspecified group (Table 15) are unknown, it is difficult to estimate with any reliability the corresponding outturn of oil. However, this group of oilseeds probably contains both decorticated and undecorticated seeds, of high and low oil content. Therefore a 35-percent outturn of oil has been arbitrarily used to relate the quantity of seed to yield of oil. On this basis the six-year average production of oil from this source is calculated at 152.6 metric tons. It is further assumed that all of this oil was consumed in edible channels.

Summary of Edible Fat Supply

The average annual supply of various individual edible fats is summarized in Table 16, and opposite each product is given the estimated per-capita consumption based on an assumed average of 4 million consumers.

It must be borne in mind that these figures represent approximate rather than absolute values, because certain assumptions had to be made in the absence of specific data and information relative to end-uses. For example, no data for coconut oil *per se* are included in Table 16. It has been assumed that practically all of the coconut oil consumed in Venezuela is used in the manufacture of soap and shortening. The edible portion of this oil, therefore, is considered accounted for in the shortening item, Table 16. On the other hand, one-half of the *"corozo"*-kernel oil, which is similar to coconut but is consumed only in small volume, is included in this table in an effort to balance the possible small quantity of coconut oil that may not have been consumed in the manufacture of soap and shortening. Some of the soft oils, such as sesame, groundnut, etc., were also consumed in the manufacture of shortening, but it is assumed that these are offset by the consumption of imported stearine (highly hydrogenated oil), which is not included in any of the tables unless under "edible oils, unspecified"; this, however, does not appear logical. No data for tallow are included in Table 16 because it is assumed to have been used almost entirely in the manufacture of soap. The small amounts of imported shortening and margarine, if any, are also not included.

It should also be realized that the data in Table 16 represent average values of unequal time intervals. It would have been preferable to base all averages on the same five-year or ten-year interval, preferably the latter, but adequate data were not available for such a comparison.

Inadequacy of Fat Supply

Table 16 indicates an average annual supply of "visible" fats of approximately 13,000 metric tons, somewhat in excess of usual estimates. For example, Kifer [5] estimated the consumption of "visible" fats in Venezuela for 1946 to be 8,300 tons. However, even this higher figure is equivalent to a per-capita consumption of only about 3.25 kilograms per year, or approximately 9 grams a day. It should also be borne in mind that the data for the oils shown in the table are for crude oils, and the figures are therefore appreciably higher than those for finished oils.

If these figures can be considered as approximately correct they represent an extremely low fat intake, even when compared with the recommended minimum levels of the Committee on Foods of the National Research Council or the Báez-Bengoa plans (see Table 2).

TABLE 16.—SUMMARY OF ANNUAL TOTAL AND PER-CAPITA SUPPLY AND CONSUMPTION OF EDIBLE FATS

Type of fat	Period	Annual total	Percent imported	Annual per-capita
		(Metric tons)		*(Grams)*
Animal				
Butter	1938–46	1,451.6	20	362.9
Lard	1941–46	4,309.9	70	1,077.5
Vegetable				
Cottonseed	1941–46	690.3	0	172.6
Sesame	1941–46	958.3	10	239.6
Groundnut	1944–46	666.5	97	166.6
Olive	1938–46	371.9	100	92.9
Corozo[1]	1941–46	413.5	100	103.4
Unspecified oil[2]	1941–46	817.9	100	204.5
Unspecified seed[3]	1941–46	152.6	100	38.1
Processed products				
Shortening	1944–46	[4]3,476.5	0	869 1
TOTAL		13,309.0		3,327.2

[1] One-half of total production considered as being consumed in edible field.
[2] Imported oil, unspecified.
[3] Oil equivalent of imported oilseed, unspecified.
[4] Data for 34 months extrapolated to three years.

The figures for per-capita consumption of fats in Venezuela refer only to "visible" consumption, or those portions of the fat supply which are items of commerce. It is also probable that these fats are largely consumed by the urban and suburban populations, less than half of the total. The Mission observed that in the oil-producing centers of Caracas, Maracay, Valencia, and Puerto Cabello fats and oils appeared to be fairly abundant, judged by their generous use in preparing foods.

The rural population probably augments its fat supply by the production of fats and oils in the home or on the farm. For example, members of the Mission visited a number of homes and talked with members of families living in the *llanos* area of Bolívar state in the vicinity of the Cuchivero River. Many of these families obtain a major portion of their cooking fat by processing the nuts of the so-called *coroba* palm, which is found in small *corobales* (*coroba* groves) growing in the vicinity of their habitations. No doubt there is also a certain amount of farm and home rendering of fat from locally slaughtered animals.

Not only is the total national and per-capita consumption of edible fats relatively inadequate for the maintenance of normal health and production of energy, but approximately 45 percent of even this low consumption depends upon imports.

To attain self-sufficiency in edible fats at the current level of consumption it would be necessary to double domestic production. To provide a daily minimum "visible" fat supply of 36 grams per person, as suggested in the Báez-Bengoa plan, would require a fourfold increase in domestic production. To provide a "visible" fat supply equivalent to that suggested as a war-emergency minimum by the Committee on Foods of the National Research Council would require a 5½-fold increase in domestic fat production.

The seriousness of the current fat deficit in Venezuela and the disastrous consequences which such a low fat consumption implies should make its solution the No. 1 problem of the nation. This problem should be attacked with every available resource of the country, and from every possible direction, by the best qualified people who can be enlisted in the work.

The Mission cannot, on the basis of limited investigations that could be made in the time allotted, indicate all the modes of approach to a solution of this problem. However, a number of suggestions can be made that should result in some immediate improvement and ultimately make possible a complete solution.

LITERATURE CITED

[1] National Research Council Reprint and Circular Series, No. 118, 1943.

[2] M. Báez. *Contribución a una Nueva Agricultura.* Caracas: Tercera Conferencia Interamericana de Agricultura, 1946. Pp. 17-19.

[3] José María Bengoa. *Medicina Social en el Medio Rural Venezolano.* 2ª ed., Caracas, 1946. P. 138.

[4] "Cultivo e industria de productos oleaginosos," *El Agricultor Venezolano, 4,* Nos. 47-48, pp. 28-34 (1940).

[5] Russell Kifer. *Fats and Oils in Latin America.* Washington: Pan American Union, 1947.

[6] *Agricultural, Pastoral, and Forest Industries in Venezuela.* Washington: U. S. Tariff Commission, 1945.

[7] According to the U. S. Department of Agriculture, *Agricultural Statistics, 1946,* p. 372, average milk production in the United States based on 12-month records completed by dairy-herd-improvement associations for 28,339 cows, was 3,730.5 kilograms a year or 10.2 kilograms a day.

[8] A. E. Bailey. *Industrial Oil and Fat Products.* New York: Interscience Publishers, Inc., 1945.

[9] C. E. Lund. *Industry Report, Fats and Oils.* Washington: U. S. Department of Commerce, January 1948.

[10] Eduardo Mendoza. *Memoria y Cuenta del Ministerio de Agricultura y Cría.* Caracas: Vol. 2, p. vi, 1946.

[11] O. W. Barrett. *The Tropical Crops.* New York: Macmillan Co., 1928. Pp. 248-274.

[12] *Boletín de la Cámara de Comercio de Caracas, 35,* No. 409, p. 11,119 (December 1947).

[13] *Venezuela. Report of the Venezuelan Commission of Inter-American Development.* Washington: Inter-American Development Commission, 1944. P. 7.

[14] Carlos Antonio Punceles. "Industria del Algodón en Venezuela," *Revista de Fomento, 7,* Nos. 58-59, pp. 133-240 (1945).

[15] Gastón Vivas Berthier. *El Algodón, Estudio Económico de un Cultivo.* Caracas: Asociación de Agricultores Algodoneros de Venezuela, 1945.

[16] Salvador Lairet. *El Algodón y la Industria Textil.* Caracas: 3ª Conferencia Interamericana de Agricultura, 1945.

[17] *Revista del Banco Agrícola y Pecuario,* No. 1, pp. 34 and 36. (January 1946).

[18] W. H. Tharp. "Cottonseed Composition: Relation to Variety, Maturity, and Environment of the Plant." In *Cottonseed and Cottonseed Products, Their Chemistry and Chemical Technology,* A. E. Bailey, ed. New York: Interscience Publishers, 1948. P. 118. *See also* ref. 8, p. 108.

[19] Number of harvested hectares 8,098,000, total production of cottonseed 4,448,000 metric tons, calculated yield 550 kilograms to the hectare.

[20] D. G. Langham and M. Rodríguez. *El Ajonjolí* (Sesamum indicum L.) *su Cultivo, Explotación y Mejoramiento.* Caracas: Publicación del Ministerio de Agricultura y Cría, Boletín No. 2, 1945.

[21] *Fats, Oils, and Oil-Bearing Materials in the United States.* Washington: U. S. Tariff Commission, 1941. P. 51.

[22] *Memoria y Cuenta del Ministerio de Agricultura y Cría,* 1946. Vol. II, p. 166.

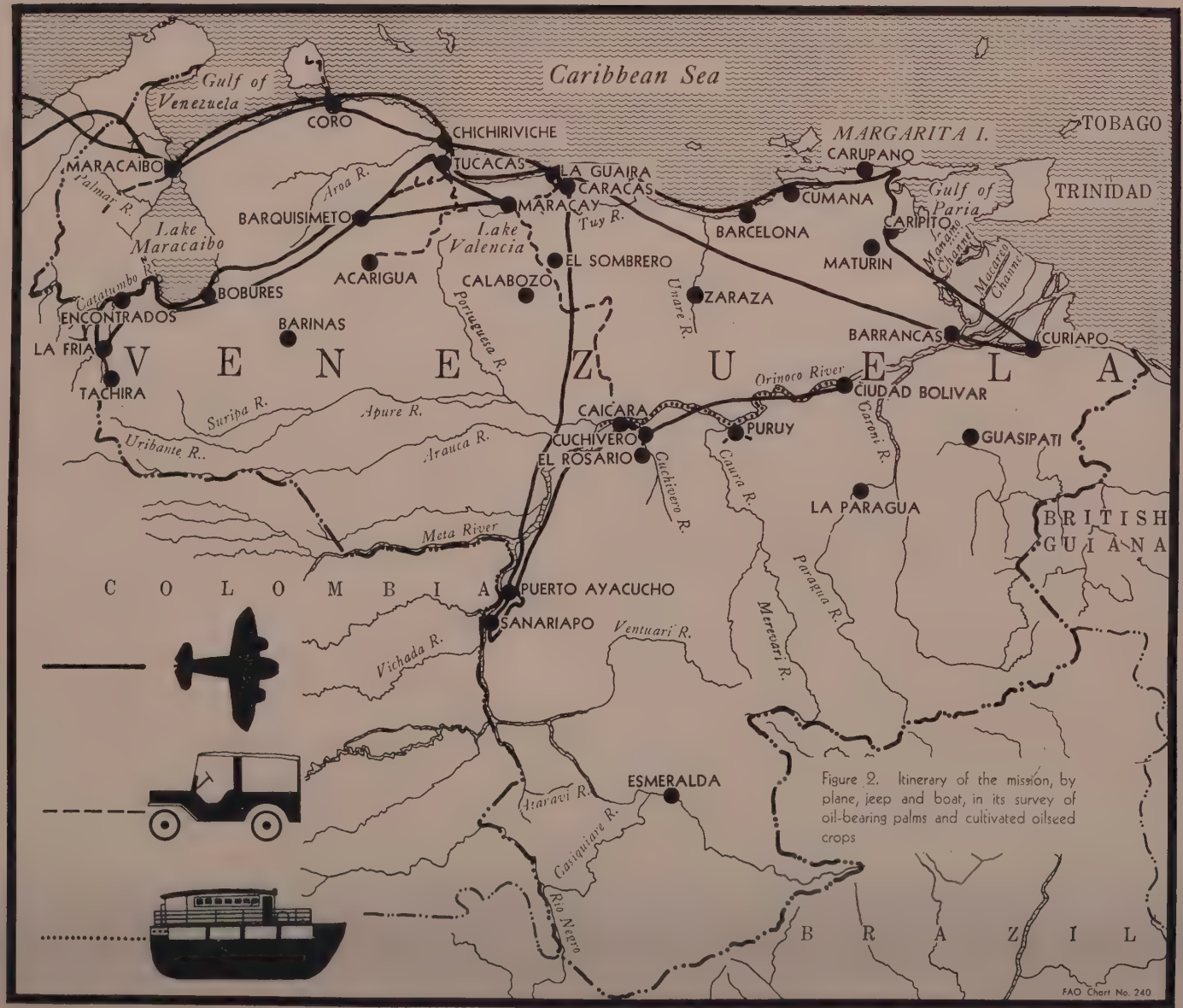


Figure 2. Itinerary of the mission, by plane, jeep and boat, in its survey of oil-bearing palms and cultivated oilseed crops

IV Field Work of the Mission

VENEZUELA has an area of 1,020,398 square kilometers (393,976 square miles). The lowland regions lie along the coast, around Lake Maracaibo, and along the deltas and river valleys, especially that of the Orinoco River, which is 2,400 kilometers (1,500 miles) long. The *llanos,* relatively dry grasslands and savannahs, comprise much of the interior. The mountainous regions include the coastal ranges, the scattered mountainous and highland areas south and east of the Orinoco, and the extensive *cordillera* of the Andes.

The principal edible oil-palm forests of these areas were surveyed by the Mission with the aid of airplane, jeep, and boat, and the main oilseed agricultural areas and the oil-processing factories were visited. The complete itinerary of the Mission is shown in Figure 2, together with the modes of travel and some of the most important areas and towns. Mission members traveled the following distances while surveying oil palms and crops: More than 5,600 kilometers (3,500 miles) in a Venezuelan Army DC-3 plane, about 1,600 kilometers (1,000 miles) by commercial airline, nearly 3,200 kilometers (2,000 miles) by jeep, and about 400 kilometers (250 miles) by boat.

The Mission obtained topographic and air-navigation maps of Venezuela from the U. S. War Department. The maps used in the survey were Air Navigation Chart No. V30-49 (1:2,188,800); AAF Aeronautical Charts 770, 771, 772, 826, 827, 828, 892, 893 (1:1,000,000), Shell *Mapa de las vías de Communicación de Venezuela* (1:1,000,000). Air-photograph mosaics of the Orinoco River and the coastal areas between Puerto Cabello and Chichiviriche were supplied by the Cartographic Institute *(Instituto de Cartografía).*

Method of Making Survey

Surveys of the potential resources of the tropical forest and jungle have, in the past, required hard labor, great expenditure of time, and considerable personal risk, especially by exposure to tropical diseases. Most of the surveys have been limited to river courses and the few roads and trails found in the tropical forests. Surveys of potential yields and values of such products as rubber, balata, chicle, quinine, palm oil, palm-kernel oil, palm wax, bamboo, mahogany, ebony, balsa, other tropical woods, kapok, tropical fruits, nuts, and other commodities have been very difficult to make.

A method was described by Jenkins [1] in 1945 for surveying tropical forests and impenetrable regions rapidly and accurately by use of the airplane. Large areas can be covered and the best producing sections can be located without arduous travel through nonproductive sections. This method was later improved by use of the aerial camera, so that exact counts of plants can be made and compared with aerial estimates. Surveying the oil-producing palms of Venezuela and palms and other plants in South and Central American countries has brought out several advantages in the use of the airplane:

Estimates made from the air save a great deal of time and expense compared with extended ground surveys. Exposure of personnel to tropical diseases is avoided or minimized. More exact delimitation of plant concentrations and more accurate definition of producing areas are possible.

Preliminary Preparation

The aerial survey entails certain preliminary preparations and procedures. One of the most important requirements is a supply of maps. A general base map is required for outlining the most promising areas. In this survey all of the data available from botanical collections, published descriptions, and native reports on palm-containing areas were assembled on the base map, and the various air-reconnaissance routes were sketched out. Detailed topographic sheets of the potential areas of production were annotated, and in some cases airphoto mosaics were obtained.

The identification of the species of palms or other plants is the most difficult part of an aerial survey and requires the most preparation. The previous experience of the surveyor is of great importance in identifying species from the air. A knowledge of the plant's appearance, form, color, and habitat is essential. Identification is facilitated by the knowledge that certain species

are found only in specific habitats—along the coast, along rivers, or only in the open savannah. Flying over definitely identified stands of the specific flora is a great help. Examination of botanic collections and lists of local flora is necessary to learn what genera and species are known to exist in the areas to be surveyed. In the present survey species determinations were rarely made from the air, but it was usually possible to distinguish the various genera. Ground surveys were necessary to collect fruits, flowers, leaves, and other parts of the palms for making exact identifications in the laboratory. The identification and estimate of palm numbers from the air requires experience which may be obtained by flying over cultivated coconut plantations. Coconuts are easily identified and are planted about 100 palms to the hectare or 10,000 to the square kilometer.

Aerial Reconnaissance

Aerial reconnaissance flights were planned to cover the most promising palm areas. The flights shown in Figure 2 follow the coast, main waterways, deltas, and lake margins where palms were likely to be found or where they had been reported. From the air, palm stands were marked out on topographic maps and airphoto mosaics. The boundaries of concentrated palm stands were determined and the percentage of the area covered with palms was estimated and noted on the maps. The boundaries of the areas containing palms were outlined on the maps, and the number of palms per hectare was estimated. These estimates were made by taking into account the size of the palm crown and the space between palms. When possible, rapid counts were made between landmarks on the maps. Tentative identifications of palms were noted on the maps. Certain species were readily distinguishable from the air, while in the case of others even the determination of genera was not possible. The most suitable locations for taking air photographs were also noted.

Aerial reconnaissance was carried out in a DC-3 airplane flying at altitudes of 200 to 1,000 meters (650 to 3,200 feet) at a speed of about 210 kilometers (130 miles) per hour. Some areas were flown several times from different directions so that the exact areas could be delimited.

The most important oil-producing palms in Venezuela belong to the genus *Scheelea*. This genus is closely related to *Attalea, Orbignya,* and *Maximiliana* and is separated mainly on characters of the male flowers. These genera could not be distinguished from the air, but ground surveys showed which genera and species were important.

In the Lake Maracaibo area *Scheelea macrocarpa* was most important. The stocky trunk, broad and elongate leaves separated it from *Jessenia repanda,* which has a taller slimmer trunk and a smaller more compact crown. This was very apparent in the aerial photographs.

In the Palma Sola area, most palms were royal palms with their tall slim whitish trunks and rather compact crowns (see Figure 3). The crowns of *Scheelea excelsa* palms are much more spreading, with longer, larger, and darker leaves; the trunks are thicker and darker, the growth habit different, and the trees are not as concentrated.

In the Orinoco area, *Scheelea macrolepis* has a distinctive habit of growing in groups called *corobales,* either in open savannah or in nearby tropical forests. The distinctive pale gray-green foliage distinguishes it from all other palms. *Scheelea humboldtiana* could not be distinguished from *Maximiliana* and *Jessenia bataua,* so that the estimates of these are combined in the Sanariapo River area.

In the savannah areas, where *Acrocomia* is most common, there were no other palms with which it could be confused. It has long pinnate leaves with thin hanging leaflets and the scattered palms have a distinctive foliage color and growth form so that they are readily identified.

Temiche palms *(Manicaria saccifera)* were found only near the ocean and the delta region of the Orinoco. The low stature, broad, more or less entire yellowish-green leaves, habit of growing in open areas or along streams made it readily distinguishable from the more abundant *moriche* palms. The *moriche* (*Mauritia minor* and other species), have clustered palmate leaves of a blue-green color. They are characteristic of the stream margins and low areas of the *llanos* and savannah. These palms grow in an almost pure stand in a large part of the Orinoco Delta.

The coconut *(Cocos nucifera)* is very distinctive, with its stiff pinnate spreading leaflets and shining, often bronzed appearance. The tall, thin, frequently bent trunks are also characteristic of this palm. It usually grows near the ocean, and, if in the interior, is planted near habitations.

Figure 3. Typical aerial photograph of dense stands of royal palms (*Roystonea*) and *corozo* palms (*Scheelea excelsa* (?)) in the Palma Sola area.

Aerial Photography

The commercially important areas of production were photographed on black-and-white film with a Zeiss aerial camera at a height of 1,000 meters (3,200 feet) and at an airspeed of about 210 kilometers (130 miles) per hour. Several color photographs were taken with a 35-millimeter camera at an elevation of about 100 meters from an angle of 45° to a nearly vertical position. The black-and-white air photographs measured 20 by 20 centimeters and covered 3.24 square kilometers. The photographs were taken with a 66 percent overlap, which eliminates peripheral distortion. Most of the areas were photographed from the air while the Mission carried on the ground survey.

The aerial photographs were analyzed by use of a magnifying stereoscope trained upon two adjacent photographs, each with a two-thirds overlap. By using this technique, the palms appeared as three-dimensional projections and the height could also be estimated. Some of the characteristics used in species identification were also used for identification on photographs. The color photos helped to identify certain stands. Since specific identifications of specimens collected by the ground surveys were available, exact identification was possible in most of the photographs. A useful method of combining ground and aerial surveys was this: In an area readily picked out from an airplane—and from aerial photos—such as the land surrounding a bridge, a hill, or houses, specimens of palms were collected and identified on the ground. The known identified palms were then noted on the aerial photographs and were used for identifying other palms from the air.

Ground Survey

It was necessary to make several detailed ground surveys and to co-ordinate them closely with aerial surveys. These were made at locations where the airplane could land in or near the palm-producing areas. The ground surveys were made by boat, by jeep, and on foot. They definitely identified species of palms, made estimates of potential yields, and obtained samples. They also obtained information on the cost and

availability of labor, transportation, health conditions, etc.

Ground determination of the number of palms was made by measuring quadrats and counting the trees. Small areas were measured with steel tapes; larger areas were surveyed by measuring distance on the speedometer of the jeep while counting palms. The annual yield of fruit per palm was determined by counting the number of bunches of fruit produced per tree, and by weighing several bunches to get the average weight. Samples of mature fruit were collected for analyses of oil content and composition of the pulp and kernel. Botanical collections were made of the fruit, male flowers, leaflets, and samples of the trunk, spines, spathes, etc., which are important in identification of the species. Notes were made of the size of palms, trunks, leaves, and any special characteristics or data on habitat and abundance. Local inhabitants were questioned about the location of stands, dates when fruits mature, and the amount of fruit and kernels used for oil. In general, the information obtained from inhabitants of different areas agreed quite well.

Samples collected for analysis were cleaned and placed in cloth bags, labeled, and shipped to the Oil, Fat and Protein Division, Southern Regional Research Laboratory, United States Department of Agriculture, New Orleans, Louisiana, to be analyzed for content and composition of oils.

The annual yield of an area was determined as follows: The sample area selected by aerial reconnaissance was measured on the maps and airphoto mosaics. The percentage of sample area containing palms was estimated from the air and by measurement on airphotos. The density of the palms was based on the aerial estimates, actual counts on airphotos and colorslides, and from counts made during the ground surveys. The per-unit density was multiplied by the area containing palms, giving the total number of palms. The annual yield per palm and percent of mature bearing palms determined from ground surveys was multiplied by the total number of palms, which gave the total annual yield of fruit per area. This was later multiplied by the percentage of oil content of kernel and pulp obtained by chemical analysis, which gave the total annual yield of oil produced in the area.

This method should provide a more accurate estimate than any large-scale method heretofore attempted. However, the degree of accuracy has not been ascertained. In a survey of this type the figures presented are probably fairly reliable as a preliminary estimate of the potential yield of large areas in somewhat inaccessible regions. More detailed surveys of specific areas should precede commercial exploitation.

LITERATURE CITED

[1] D. W. Jenkins. "Use of the Airplane in Vegetation Surveys," *Ecology, 26,* 413-414 (1945).

Figure 4. Typical coconut plantation along the Caribbean coast between Puerto Cabello and Tucacas.

V Oil-Bearing Palms

CULTIVATION of oil palms in the Western Hemisphere is far behind that in some other parts of the world. The coconut is cultivated to a limited extent in Central America, the West Indies, and South America. The African oil palm has been cultivated in Brazil and small experimental plantations have been established in several other countries, including Venezuela. The American oil palm *(Corozo oleifera)* has been suggested as a possible source of palm oil. Since the highest oil yield of any known cultivated crop is obtained from the African oil palm, its possibilities in Venezuela were considered by the Mission to merit special study.

Information is relatively meager concerning wild palms yielding edible oil in South America. Many of the species are poorly described, some are misidentified, and knowledge of the distribution of various species is limited. The potential production and yields are almost unknown except in certain limited areas, such as Brazil, where commercial exploitation is practiced to some extent.

In Venezuela, as in other tropical countries, it has been known in a general way that large resources of edible oils exist in the tropical forests. Estimates of potential yields and production from these sources have been difficult to make in widely scattered areas with limited means of transportation. In surveying the wild-palm resources of Venezuela, the Mission used methods developed by Jenkins [1, 2] in surveying the wild palms of Central America and Mexico.

Figure 5. Workman climbing tree to harvest coconuts. Same plantation as Figure 4, opposite.

Cultivated Palms

Coconut Palm (*Cocos nucifera*)

The coconut *(Cocos nucifera)* is cultivated in large numbers in many of the coastal areas of Venezuela (see Frontispiece, Figures 4, 5, and 6). Copra is processed in the various oilmills of Venezuela and in many cases constitutes the main raw material used for oil production. Some coconuts are consumed before they are ripe for drinking coconut milk and after they are ripe for making shredded coconut and confections. Oilmill operators estimate that less than 5 percent of the coconut crop is consumed for these uses.

An aerial survey was made of the coconut plantations while flying at low altitudes. Estimates of the size of stands were made by actual count of palms on one side of the plantation. By blocking out squares of the palms their num-

bers could be quickly counted, or accurately estimated. The average spacing was about 10 meters between palms, about 100 palms to the hectare, or 10,000 palms to the square kilometer. A correction factor was applied in a few areas with different spacings. The coastal areas surveyed by air were from Chichiviriche to Puerto Cabello and La Guaira, including the states of Carabobo, Aragua and part of Falcón. From La Guaira, the coast was surveyed to Yaguaraparo, including the states of Miranda, Anzoategui, and part of Sucre.

The area from San Juan to east of Puerto Cabello, state of Carabobo, was surveyed first by aerial reconnaissance and then by counting palms on detailed aerial mosaic photographs, which showed the coconut plantations clearly. The number of palms was noted and the area under cultivation was measured. The airphotos were checked and the location and extent of the plantations were corroborated from a plane. The aerial estimates were then checked by analysis of aerial photographs, and the two sets of data were averaged.

Information on the number of coconut palms now cultivated in Venezuela is summarized in Table 17. These data were compiled from air reconnaissance, analysis of aerial photographs, and from other sources. The computations of the Mission are compared with previous estimates of the Bank of Agriculture and Livestock [3] and *El Mes Financiero y Económico* (Finance and Economics Monthly).[4] Data for the state of Zulia in 1948 were supplied to the Mission, and collected information is used for several states where the area was not completely surveyed.

Estimated Yield of Oil. The Mission estimates that there are approximately 1,556,200 coconut palms in Venezuela on an area of about 15,600 hectares.

On the basis of limited observations by the Mission and statistics furnished by Venezuelan authorities, the average yield per palm is five coconuts a month or about 60 a year. Production is highest near the coast, where some palms produce up to 90 coconuts a year, while diseased palms and those in the interior yield only about 15 coconuts each per year. Assuming an average of 60 coconuts per tree, yearly production would be about 93,372,000 coconuts.

But estimates of the number of palms and the area they occupy vary considerably. According to Montaner,[5] total production of coconuts in 1937 was 28,616,651. Data supplied to the Mission by the Venezuelan Development Corporation indicated that, on an average from 1941 to 1946, 50,000,000 coconuts were produced on an area of 16,700 hectares. Finance and Economics Monthly [4] places the total annual production at 32,000,000 coconuts.

TABLE 17.—ESTIMATES OF THE NUMBER OF COCONUT PALMS IN VENEZUELA

Location	FAO Mission 1948	*Banco Agr.* 1945	*Fin. y Econ.* 1945
Zulia (Total)	[1]*430,837*	180,360	83,000
Bolívar	2,498		
Urdaneta	51,705		
Páez	208,418		
Miranda	28,746		
Mara	139,470		
Falcón (Total)	*442,000*	331,700	116,700
San Juan Airphoto 787	82,000		
Tocuyo 786	300,000		
Tucacas 785	60,000		
Lara	[2]*8,300*		8,300
Carabobo (Total)	*323,000*	125,000	100,000
Airphoto 784	110,000		
Morón 783	90,000		
Mármol 782	5,000		
Ganago	15,000		
Borburata	10,000		
N. Pto. Cabello	65,000		
S. Pto. Cabello	28,000		
Aragua	[3]*66,660*	66,660	13,300
Federal District	[2]*36,700*		36,700
Miranda (Total)	*48,000*	50,000	11,700
Carenero	6,000		
Macurucuto	42,000		
Anzoátegui (Total)	[3]*30,000*	30,000	18,500
Unare	3,000		
Barcelona	2,000		
Guanta	10,000		
Sucre[4] (Total)	[3]*142,500*	142,500	116,700
Cumaná	22,000		
Marigüitar	5,000		
Cariaco	10,000		
Casanay	5,000		
Yaguaraparo	1,000		
Nueva Esparta	[2]*16,700*		16,700
Monagas	[2]*1,700*		1,700
Amacura Delta	[2]*10,000*		10,000
VENEZUELA (Total)	1,556,197	925,720	532,600

[1] Data supplied to the Mission.
[2] *El Mes Financiero y Económico* (Financial and Economic Monthly), 1945.
[3] *Banco Agrícola y Pecuario* (Bank of Agriculture and Livestock), 1945.
[4] Total coconut palms for one-third of state surveyed by air, 43,000.

Figure 6. Distribution of coconut and *corozo* (*Acrocomia*) palms in Venezuela.

On the basis of estimated yield of copra and oil content, it appears to the Mission that 10 coconuts produce 1 kilogram of coconut oil. At this rate, if all the 93,372,000 coconuts of Venezuela were processed for oil they would yield a total of 9,337 metric tons annually, or a ratio of 600 kg./ha.

Venezuelan Development Corporation figures indicate that the annual production of oil (average, 1941-46) is 6,600 metric tons, slightly

more than 395 kg./ha. The Bank of Agriculture and Livestock places the output at 6,000 metric tons, according to a memorandum by Dr. A. Cervini. The Finance and Economics Monthly [4] estimates the total production (based on 32,000,000 coconuts) at 2,500 metric tons of copra and 2,000 metric tons of coconut oil. These latter ratios would require 16 coconuts to produce 1 kilogram of oil, if all coconuts were used for this purpose.

Kifer [6] says that the consumption of coconut and other palm oils in the Western Hemisphere is in excess of 350,000 metric tons annually, and the total production of coconut and other cultivated palm oils in the tropical Americas is not more than 50,000 metric tons. Crawford [7] estimates the total production of coconut oil in the tropical Americas, not including Venezuela, to be about 46,000 metric tons.

Diseases. The coconut palm in Venezuela is being attacked by "red ring," a disease caused by a nematode *(Aphelenchus cocophilus).* This disease causes extensive damage and results in decreased production of coconuts. It has been observed principally in the area of Puerto Cabello.

Several insects also attack the coconut palm. The Entomology Branch *(Departamento de Entomología),* Ministry of Agriculture and Livestock, reports that *gorgojo del coco (Ryncophorus palmarum* L.) and *congorocho (Strataegus aloeus* L.) have been observed to attack coconut palms in Venezuela. These beetles, measuring from 4 to 6 centimeters in length, cause damage to the trunks of young or diseased trees in all producing areas of Venezuela. Other beetles attacking the trunks are *Rhina barbirostris* L. and *Xylelorus confusus* Eich. *Carcoma,* a lepidopterous larva of the genus *Castnia,* attacks the bases of the leaves. Scale insects *(Aspidiotus destructor* Sign.) and others attack young leaves, growing areas, and flowers, causing a decrease in the production of fruit.

African Oil Palm (*Elaeis guineensis*)

The African oil palm has been grown successfully in several parts of the world, but its development as an American oil crop is in the experimental stage. The annual yield of oil per hectare of this palm is higher than that of any other cultivated edible oil crop. Cultivation of this palm on a large scale in the Western Hemisphere offers considerable promise in helping to meet the oil requirements of an expanding world population and of preventing future recurrences of the present oil shortage.

World Production. The African oil palm has been used by the people of West Africa for several centuries. About 1842, palm oil attracted outside attention and became increasingly important as an export commodity. About 1910, plantation methods were applied to the vast forests of wild oil palms in West Africa. A few thousand hectares were planted during this early period, and by 1943 about 110,000 hectares of cultivated stands were reported in the Belgian Congo. This area exported to the United States 15,910 metric tons of palm oil in 1946, 24,000 metric tons in 1947, and the 1948 export is expected [8] to equal the 1947 figure. During the period 1936-39, the average annual production of palm oil in West Africa was 240,910 metric tons, of which about 20 percent was exported to the United States.

The African oil palm was introduced into the Dutch East Indies in 1848. In 1910 plantations were started in Sumatra, and by 1914 about 2,600 hectares had been planted. By 1932 about 62,000 hectares had been planted, of which 38,350 hectares in production yielded 85,000 metric tons of palm oil. The average annual production for the period 1936-39 was 193,200 metric tons, of which 60 percent was exported to the United States. Plantations were started in British Malaya in 1918 and by 1932 covered about 24,410 hectares.

The average annual world production of palm oil for the period 1934-38 was 745,000 metric tons,[9] of which 445,000 metric tons was exported. The United States imported 186,820 metric tons of palm oil valued at $23,000,000 in 1937, 140,000 metric tons in 1941, an annual average of 28,182 metric tons during 1942-46, and 26,000 metric tons in 1947. While the importation of palm oil from the Belgian Congo has increased recently, the East Indies, which is the main source, has not come back into full production. According to Skeen,[8] the Japanese, during their occupation of Sumatra, destroyed the main processing facilities and the plantations were neglected for about six years.

African Oil Palm in the Western Hemisphere. The African oil palm appears to be well adapted to the Western Hemisphere. It has been planted, at least experimentally, in nearly all of the countries of Central America. The United Fruit

Company has had experimental plantings under study for about 20 years and has initiated a planting program on 2,700 hectares of old banana lands near Parrita on the Pacific coast of Costa Rica.[10] Plantings have also been made in Honduras near Tela. In Guatemala, a plantation of 10,000 ten-year-old palms is in production near Escuintla. In other areas along the Pacific coast experimental plantings have been made near San José, La Democracia, and San Antonio Suchitepéquez, where trees have come into production.[11]

The African oil palm grows well in the West Indies, and is quite abundant in Haiti, where it is an important native subsistence crop. It is said to have been introduced into Jamaica from Africa before 1688. It was first scientifically described by Jacquin in 1763 from specimens introduced into Martinique. It also grows well in Trinidad and Puerto Rico.

In South America, the African oil palm has been introduced into Brazil, Venezuela, Colombia, British Guiana, and Peru. It was planted in Brazil several centuries ago and is found in Bahía and Amazonas. A United States Vegetable Oil Mission,[12] studying the fat and oil situation in Brazil in 1941, found that several Brazilian states were suitable for production of this palm on a plantation basis. The plant, known in Brazil as *dendê,* is widely distributed in the state of Bahía, which has an estimated 1,500,000 trees; 300,000 of these grow on Itaparico Island. On the basis of yields from Africa and the East Indies, if all the trees were producing, they would yield about 22,700 metric tons of pulp oil and nearly 600 metric tons of kernel oil annually.

The FAO Mission visited the plantation of the Venezuelan Banana Company *(C. A. Bananera Venezolana)* in the state of Carabobo, Venezuela. About 100,000 palms are being planted on an irrigated banana plantation where bananas have suffered severe damage from *sigatoka* disease. About 25,000 seedling oil palms have been transplanted and are growing well. The oldest trees (4½ years) are producing fruit (see Figures 7, 8, 9, 10).

In Peru at the Central Colonization Settlement *(Estación Central de Colonización),* colonists have planted African oil palms in the vicinity of Tingo María and a program of selection and cultivation is being carried on. The varieties known as Sumatra, Java, Diwakkawakka, and Deli, received from Honduras, are being tested along with *Macrocarya* from Iquitos, which was planted

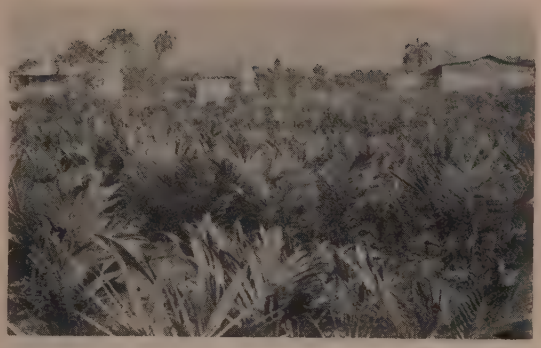


Figure 7. African oil palm seedlings in field nursery of the Venezuelan Banana Co.

in 1932. This variety was brought from the Island of Fernando Po, West Africa, but it originated in the Belgian Congo. A few plantations of older palms are also found in Peru.

Cultivation. The African oil palm requires a warm climate, abundant sunshine, and an annual rainfall of 1,500 millimeters or more. The oil palm is sensitive to drought and the rainfall must be well distributed throughout the year, with no marked dry period unless irrigation is provided. In Venezuela, the palms grow and produce well through the dry season on irrigated land. Growth is best at altitudes below 300 meters.

This palm grows in a variety of soils, but does best in deep, well-drained, moist humus and

Figure 8. Bananas interplanted with African oil palms, Venezuelan Banana Co., near the Yaracuy River, state of Yaracuy.

Figure 9. Four-year-old African oil palm, originally interplanted in a banana plantation.

Figure 10. Bunches of fruit at the base of the African oil palm shown in Figure 9.

loam-type soils. Some of the most productive soils are fairly low in lime, phosphate, and potash, but are rich in humus. The palm does not grow well in heavy or swampy soils with poor drainage, or in light sandy soils.

The palm is propagated from seed, which should be selected from heavily bearing trees having fruit of high oil content. It is preferable to select fruits with a thick pericarp, a thin shell, and a large kernel.

Careful germination experiments were carried out in British Malaya, as reported by Curtler,[13] to determine the most effective procedures. Bunting, Georgi and Milsum[14] say that these trials revealed the best results by planting in the dry season in open sand beds, using only seeds from freshly ripe fruits, from which the pericarp has been removed.

In British Malaya, germination requires two months or a little longer; the seedlings are then transferred to nursery beds. After about nine months to a year they are ready to set out in the field.

In Venezuela, the seeds are planted in sand-charcoal frames. About one to two months following emergence the seedlings are transferred to sand frames (Figure 11) and several months later to the field nursery. After about a year they are ready for field planting. In Malaya, seeds are planted just below the surface of pure sand in prepared nursery beds exposed to full sun and watered heavily twice daily.[15] Two- to three-months-old seedlings are then removed and planted 40 to 50 centimeters apart in a prepared flat nursery bed. After 8 to 10 months, the seedlings are transplanted into the field about 8.5 meters apart, or at the rate of 139 palms to the hectare. The holes for transplanting should be 75 centimeters square and 75 centimeters deep, and the seedlings should be covered with good soil up to the base of the leaves. An area of about a meter on each side of the seedling should be cultivated three or four times a year.

Experimental plantings have been made on irrigated banana lands in Venezuela and Costa Rica. Banana plants suffering from *sigatoka* disease are left standing to provide partial shade for the young palm transplants. Growth under these conditions has been excellent and the palms produce fruit in about four years.

Plantations should be kept free of weeds and may be plowed and harrowed or interplanted with leguminous crops. According to Eaton,[15] the lower fronds beneath the bunches of fruit

are often pruned in the third or fourth year. The palms produce separate male and female inflorescences on the same tree and artificial pollination is sometimes practiced to obtain higher yields, but according to Dalziel[16] this process exhausts the trees and the soil.

Bunches of fruit can be gathered from the ground until the palms are about 12 to 15 years old, but after the trees are about 10 meters high and fully mature they must be climbed to gather the fruit. It is important that the fruit be sterilized or processed quickly to avoid lipolysis, a process that produces high free fatty acid and glycerol from the neutral fat of the pericarp.

The African oil palm is quite variable. By selection and breeding it has been possible to obtain high-yielding strains. With intensive research the yields can probably be increased further. Many varieties and strains have been named and their characteristics described. In general, the African types are variable in shape of fruit and thickness of shell and do not breed true, while the fruit from Malaya is said to be heavier and richer in oil. According to Dalziel,[16] the yield of fruit is greater and the oil content higher from plants grown in equatorial rainy regions than from plants grown in areas having a prolonged dry season. Some of the most important commercial varieties are listed below.

Congo type (var. *macrocarya*), from the Belgian Congo, is thick-shelled. Deli type (var. *dura*), from Sumatra and British Malaya, is one of the important commercial types and has large thin-shelled fruits. Lisombe type (var. *tenera*), is thin-shelled but does not breed true. Pisifera type (var. *pisifera*), has no nut shell and does not breed true. The content of the pulp and kernel oils and the composition of these varieties and others are presented in detail by Eaton.[15]

The annual yield of African oil palm, while variable, is consistently high in comparison with other oil-producing plants and has increased steadily. Eaton[15] reported in 1925 an annual yield of 2,270 kilograms of palm oil and 550 kilograms of kernel oil per hectare. In the Netherlands Indies the average yield of palm oil in 1936 was 2,581 kilograms per hectare, while in 1940 it rose to 3,233 kilograms.[9] In Malaya, a conservative estimate of the annual yield is 2,000 kilograms of palm oil and 500 kilograms of kernel oil per hectare.

Analysis of Fruit and Oil. The African oil palm has a full crown of pinnate leaves, and the compact spiny fruit bunches are wedged at the bases of leaves. The trees normally bear two to six bunches of fruit a year, but as many as ten bunches have been observed. The bunches, including the central stem and branches, have an average weight of 4.5 to 16 kilograms, but may weigh as much as 40 kilograms. The bunch may contain from 1,000 to 2,000 individual fruits constituting 60 to 65 percent of the total weight.

The fruit is 2.5 to 5 centimeters in length and from 2 to 2.5 centimeters in diameter, yellow to orange or shining black in color when mature, depending on the variety, and weighs from 3 to 25 grams, averaging about 6 to 8 grams. Palm oil is derived from the fleshy pericarp or

Figure 11. Seedlings of African oil palm in sand-culture frame.

pulp, which is 48 to 75 percent of the fruit. The kernel is 8 to 25 percent of the total weight of the fruit. The oil content of the pericarp ranges from 30 to 80 percent, and of the kernel 44 to 53 percent.

The physical and chemical characteristics of palm oil and palm-kernel oils, according to *Official and Tentative Methods of the American Oil Chemists' Society*,[17] are given in Table 18.

Palm oil is principally used for making soap, and to a lesser extent in the manufacture of margarine, shortenings, candles, lubricating greases, and in the cold-reduction process of making sheet steel. An important use in the United States and England is in the manufacture

TABLE 18.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF PALM AND PALM-KERNEL OILS[17]

Characteristics	Palm (African-Sumatran) oil	Palm-kernel oil
Sp. gr. at 99/15°C.	0.849–0.856	0.860–0.873
Sp. gr. at 15/15°C.	0.921–0.925	.....
Sp. gr. at 25/25°C.	0.914–0.918	.....
Refractive index at 40°C.	1.453–1.456	1.449–1.452
Iodine value	44–54	14–23
Thiocyanogen value	46	22
Saponification value	195–205	245–255
Unsaponifiable matter, percent	Below 1	Below 1
Titer, °C.	40–47	20–28
Acetyl value	15–23	.....
Melting point, °C.	27–50	24–26
Reichert-Meissl value	Below 0.5	4–7
Polenske value	Below 0.5	9–11
Saturated acids, percent	44–46	65–82
Unsaturated acids, percent	48–52	18–24
Special characteristics	Contains carotene	Over 50 percent lauric acid

[17] Refers to literature cited at end of chapter.

of tinplate and terneplate. The United States uses about 20,000 metric tons a year for tinplating.[18]

Palm oil contains a large amount of carotene, a precursor of vitamin A. According to Poe and Fehlman,[19] analyses of 32 samples of palm oil averaged 78.2 parts per million of β-carotene, equivalent to 132 international units of vitamin A, and the highest sample contained 251 parts per million of β-carotene, equivalent to 251.6 international units vitamin A.

Palm-kernel oil is used for many of the same purposes as coconut oil, such as the manufacture of soap, shortening, margarine, etc. Palm-kernel cake is a good livestock feed. The press cake or extracted meal contains 16 to 19 percent protein, 38 to 48 percent carbohydrates, and 2 to 10 percent residual oil, depending on the method of processing.

Insect Pests and Diseases. No serious insect pests or diseases have been encountered so far in the Western Hemisphere that would make cultivation of the African oil palm hazardous. However, the large curculionid beetle (*Rhyncophorus palmarum* L.) was observed attacking cultivated African oil palms in Venezuela and Guatemala. The larva is 7 to 8 centimeters in length and is usually found in damaged, sick, or very young plants. The adult beetle is about 5 centimeters long and has a beak about 1 centimeter in length. Control consists of collecting larvae and adults by hand, by bait-trapping, and by removing damaged and sick palms. The rhinoceros beetle (*Oryctes rhinoceros* L.) has caused death of some oil palms in Brazil. In Guatemala, the beetle *O. nasicornis* has been reported to damage palms. The bruchid beetle *(Pachymerus nucleorum)* is found in the fruit in British Guiana and Brazil. The larvae eat the kernels and are a severe pest in Brazil.

A bacterial disease has been noted in Guatemala. The red ring disease of coconut might spread to the African oil palm. In Costa Rica no serious diseases or insect problems were reported, but young, recently transplanted palms were damaged by rats. This type of damage was controlled by surrounding the transplants with a narrow strip of hardware cloth.

American Oil Palm (*Corozo oleifera*)

The American oil palm *(Corozo oleifera)* could become an important source of oil if it were cultivated in plantations and if the yields of fruit and oil could be made comparable with those of the African oil palm. These two palms are similar in many respects. Both produce pulp oil and kernel oil. The pulp oil of the American species is also rich in pro-vitamin A. The American palm does not grow as tall as the African species, which makes harvesting simpler and less costly. *Corozo oleifera* palms have the added advantage that they grow in wet, swampy land, even under conditions of seasonal drought without irrigation. This opens up the possibility of using different types of land for palm cultivation.

The American oil palm has long been mistakenly identified as *Elaeis melanococca* which is a form of the African oil palm. Although in different genera, the American and African oil palms are closely related.

Distribution and Yield. Corozo oleifera is found along the coasts and river valleys in Mexico, Central America, Colombia, Brazil, and may be present in Venezuela, but it was not observed by the Mission. It has been reported from the following localities:

Mexico
Pacific coast, especially in Jalisco state.

Nicaragua
Escondido Valley and Bluefields.

Costa Rica
Pacific coast, Palmar, and near United Fruit Company plantations.

Panama
Coclé, along coast
Colón, Gatun Lake
Chiriquí
Panama, Panama City, and Chagres River.

Colombia
Bolívar, Cartagena, valleys of the Magdalena, Sinú, Lower Cauca, and Cesare
Magdalena, Riohacha
New Granada, Tocaima, Chocó, Darién.
Lower Atrato.

Brazil
Upper Amazon region
Manaus.

The usual habitat of this palm is in valleys, along the seacoast, and swampy areas, sometimes in standing water. It is rarely found on exposed dry land or in well-drained areas, but rather in shady forests or in open cleared areas near water. It is occasionally abundant and dense in wet forested areas, where it forms a part of the secondary or intermediate forest layer. While the palms are most common along low coastal areas, they are also found at higher elevations along streams.

The American oil palm is readily recognized. The most outstanding characteristic is its short, thick, frequently prostrate trunk. The palm is not tall, and the heavy clusters of fruit can be reached from the ground. The leaves are pinnate and erect. The fruits are red-orange in color, from 2.5 to 3 centimeters in length, oblong in shape, pointed, and with the surface marked by fine longitudinal striations. The fruit cupules are 5 to 10 millimeters long and remain attached to the fruit. Under the outer husk is a yellowish pulp containing palm oil. The hard black inner shell is about 1.5 centimeters in length and has three pores or openings at the top. The kernel (Figure 12) is small and short-oblong.

The American oil palm is known in local areas by the following names: Mexico (Jalisco), *coquito de aceite;* Costa Rica, *coquito, palmiche;* Panama, *corozo colorado, corocito colorado, corocito negro;* Colombia, *corozo, nolí, ñolí, yolí, corozo manteca, corozo del Sinú, corocito, corozo antá;* Nicaragua, *hone;* Central America, *ajou;* Brazil, *cayaúe, caïaúe, caïahúa, dende do Pará, dendezeiro do Pará.*

Its potential yield cannot be estimated because its distribution and range are not completely known. In Mexico, it grows in fair numbers along the Pacific coast from Jalisco southward. No

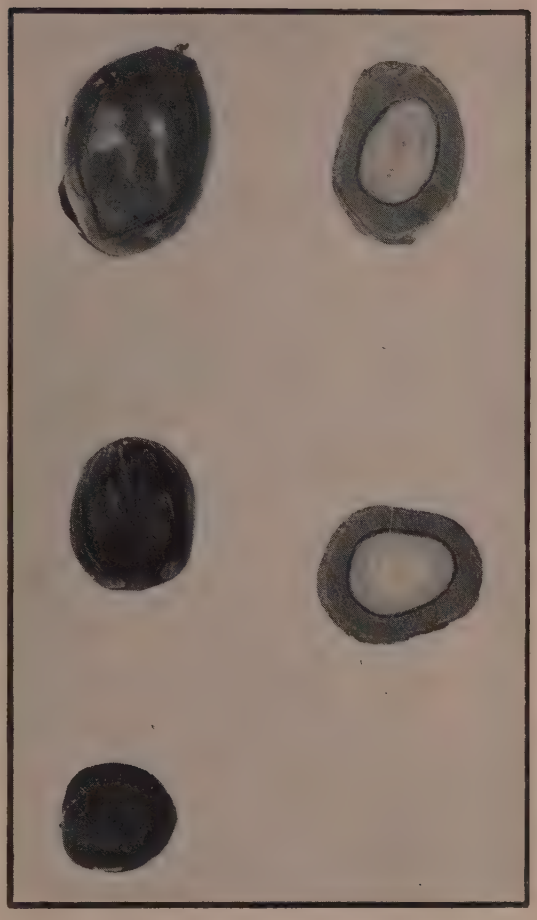


Figure 12. Fruit of American oil palm (*Corozo oleifera*) collected in Panama. (Natural size.)

estimate has been made of probable production. The palm fruit is used locally by the Indians.

Jenkins surveyed these palms in the Canal Zone and the Republic of Panama, including parts of the provinces of Panama, Coclé, Colón, and Chiriquí. In the Canal Zone it was estimated that 200 metric tons of fruit were produced annually. The partial survey in Panama indicated a minimum estimated yield of 200 additional tons; however, the total annual yield would be much larger for the whole country. In the Chiriquí region, in areas near the United Fruit Company, the potential production of an area of about 30,000 hectares has been estimated at approximately 150 metric tons. A preliminary estimate, subject to revision, of the total annual

yield of the Republic of Panama and the Canal Zone is approximately 1,000 metric tons.

The present production in terms of kernels or oil sold is very small. Jamieson [20] says that "this oil is not produced on a commercial scale." The palm furnishes a very important part of the diet of the inhabitants, especially in Panama, where a large percentage of the fruit is used locally as a source of cooking and edible oil. Several species of wild animals eat the fruit, especially the oily outer cortex. In Nicaragua, the pulp is used for poultry and hog feed and the kernel is used as a source of cooking oil. In many parts of Colombia the pulp oil is used as a substitute for butter and the kernel oil for cooking, for soap, and as a luminant.

A special study was made of the American oil palm in Panama for purposes of comparison with the African oil palm in this hemisphere. The palms studied, at Old Panama, grew in open pastures exposed to the sun. Each palm bore an average of five bunches of fruit, and four to five bunches of male flowers. The trunks of about 100 palms examined were all semiprostrate and the bunches were about 1.5 meters above the ground. The upright portion of the trunks to the base of the leaves averaged about 2 meters. The leaves were approximately 4 meters long. The usually curved, prostrate part of the trunks averaged about 4 meters long.

Analysis of Fruit and Oils. The reddish orange-colored fruit of this species matures during the dry season, from January to May or June. Some of the more exposed fruit matures early and drops to the ground. On 9 February 1948, an average-sized bunch was collected for analysis. It measured 51 by 28 centimeters and was elliptical in shape. The weights were: Total 8.20 kilograms, fruit 5.0 kilograms or 61.6 percent, lateral branches 1.82 kilograms, central stem 1.37 kilograms. It contained 1,570 full-sized fruit, and many small pulpy fruit at the ends of the stem branches which lacked a central nut. The average palm produces 40 kilograms of bunches, yielding about 25 kilograms of fruit. The distribution of the component parts of the fruit is given in Table 19.

The kernel oil is similar to African palm-kernel oil. The oil and moisture content of kernels in the Panama sample were 29.3 percent and 15.0 percent respectively. Other reported analyses indicate an oil content of 34.7 to 50 percent. The known characteristics of the kernel oil are presented in Table 20. The pulp or pericarp from the Panama sample contained 30.6 percent oil and 22.5 percent moisture. An anonymous report [21] on a specimen of so-called *noli* palm *(Elaeis melanococca)* from South America, which is probably identical with *Corozo oleifera,* indicated that the pericarp contained 29.0 percent oil and

TABLE 19.—DISTRIBUTION OF COMPONENTS OF THE FRUIT OF THE AMERICAN OIL PALM (*Corozo oleifera*)

Component	Panama		South America[21]	Brazil[22]
	Mature	Undeveloped		
	(*Percent*)			
Pericarp	27.2	85.4	16	26.6
Shell	54.5	14.6	62	58.0
Kernel	18.1	....	22	16.0

[21, 22] Numbers refer to literature cited at end of chapter.

TABLE 20.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF AMERICAN PALM-KERNEL OIL

Characteristics	Panama		Brazil	South America
	FAO Mission	Blackie[23]	Pesce[22]	Anon.[21]
Refractive index, $n_D^{40°}$	1.4513	.....	.....	.....
Iodine value	30.95	15.4	25.5	27.7
Saponification value	225.5	245.7	232.5	234.0
Unsaponifiable matter, percent	0.74	.....	.....	0.8
Reichert-Meissl value	1.65	.....	.....	[1]1.4
Polenske value	3.32	.....	.....	[2]3.0
Free fatty acids, percent	0.27	.....	0.55	[3]0.6
Melting point, °C	31.5–32.5	.....	[4]30.2	[4]26.9

[1] Soluble, volatile acids, percent.
[2] Insoluble, volatile acids, percent.
[3] Acid value.
[4] Solidification point of fatty acids.
[21, 22, 23] Refer to literature cited at end of chapter.

TABLE 21.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF AMERICAN PALM PULP OIL

Characteristics	Panama		Brazil	South America
	FAO Mission	Blackie[23]	Pesce[22]	Anon.[21]
Refractive index, $n_D^{40°}$	1.4618	.....	.....	.....
Iodine value	84.8	87.1	78.2	83.5
Saponification value	186.6	187.1	197.1	199.0
Unsaponifiable matter, percent	1.18	1.54	.....	0.7
Acid value	[1]1.12	.....	29.8	29.7
Reichert-Meissl value	0.44	.....	.....	[2]0.7
Polenske value	0.8	.....	.....	[3]0.5
Melting point, °C.	13–14	.....	[4]21.9	[4]33.6

[1] Free fatty acids as per cent palmitic.
[2] Soluble volatile acids, per cent.
[3] Insoluble volatile acids, per cent.
[4] Solidification point of fatty acids.
[21, 22, 23] Refer to literature cited at end of chapter.

8.1 percent moisture; a Brazilian specimen cited by Pesce [22] was stated to contain 47 percent of pulp oil. The pulp oil is orange-colored, semiliquid, has an odor and taste similar to African palm oil, and can be used for the same purposes. The physical and chemical characteristics of the oil are presented in Table 21.

A study was made in 1939 by Blackie and Cowgill [23] of the occurrence of carotene in the pericarp and kernel oils of *Corozo oleifera*. These oils were examined for the presence of carotenoids by chemical and spectroscopic methods, and a lipochrome of the carotene type was found. A biological assay of the vitamin A content was made on white rats. The pericarp oil contained the equivalent of 158 international units of vitamin A per gram. This specimen was obtained from the Chagres River, Republic of Panama. Both the kernel and the pulp oils of the American palm are used extensively by residents of this region for cooking, and are said to provide them with their principal and possibly only source of pro-vitamin A.

The pulp oil from the sample of fruit collected at Old Panama was analyzed spectrophotometrically at the Southern Regional Research Laboratory, New Orleans, U. S. A. The spectrophotometric curve resembled that for carotenes. The total carotene content was determined by the tentative chromatographic procedure of the Association of Official Agricultural Chemists. Three determinations gave 231, 233, 238 (average 234) p.p.m. of total carotene. If all the carotene was β-carotene, it would be equivalent to 398 international units of vitamin A per gram of oil.

Wild Palms

The wild oil-bearing palms of Venezuela are usually tall trees having relatively large fruit with thick, hard nut shells and one or more kernels containing a coconut- or lauric acid-type oil. They abound in localized areas and are potentially important as a source of edible and industrial oils. All of the exploitable species investigated by the Mission belong to the genus *Scheelea*.

The identification of species of the genera *Scheelea, Attalea,* and *Orbignya* is very difficult. Male flowers are necessary to determine the genus; and fruits, flowers, and leaves are usually required for specific identification. In *Scheelea,* the anthers of the six stamens are straight, in contrast to those of *Orbignya,* which are spirally twisted or coiled. The three petals of the male flowers of *Scheelea* are distinctive in being fleshy and club-shaped and much longer than the stamens.

Scheelea species listed from Venezuela are:

Coroba (S. macrolepis)—Described from near Ciudad Bolívar on male flowering branch only.

Yagua (S. passargei)—Described from Venezuelan Guiana on fruit only. May be the same species as *S. macrolepis.*

Yagua (S. humboldtiana)—Described from the mouth of the Vasiva River.

Coroba (S. macrocarpa)—Described from Yaracuy and Tuy rivers.

Corozo, yagua, palma de vino (S. excelsa (?))—Identification uncertain, not previously reported from Venezuela.

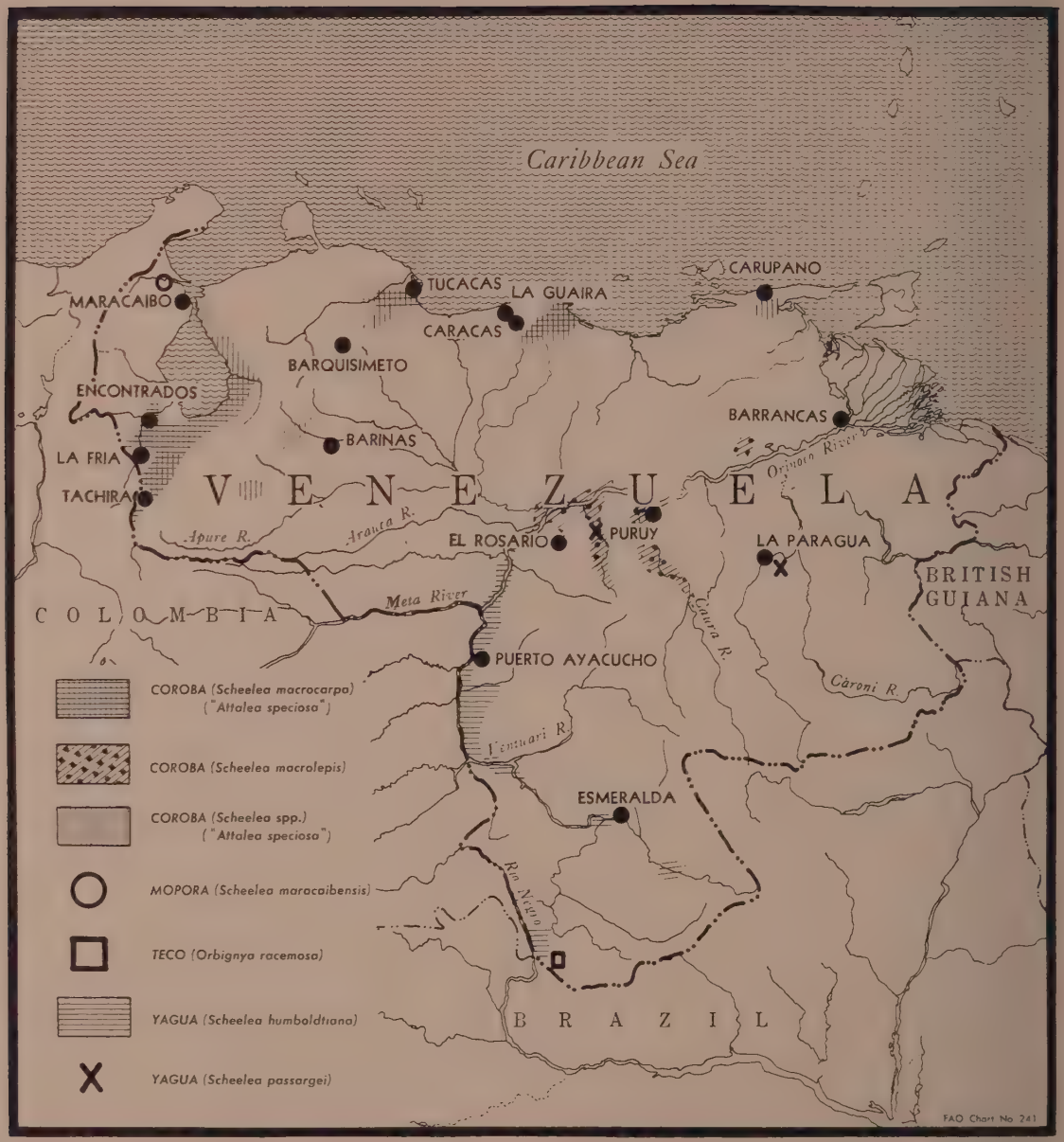


Figure 13. Known distribution of *coroba, mopora,* and *yagua* palms (*Scheelea*) and *teco* (*Orbignya*) in Venezuela.

Mopora (S. maracaibensis)—Described from near Maracaibo on fruit only. Anthers unknown, may not be *Scheelea.*

Attalea species reported from Venezuela are:

A. humilis. Woods near Barlovento.

Coruba, serisarare ("A. speciosa" (?))—Identifications in Venezuela not certain.

Orbignya species reported from Venezuela are:

Teco (O. racemosa)—Reported from Río Negro and Río Guasié.

Coruba, corozo, palma de agua (O. cohune (?))— Reported by Grünwald, 1947, identified by Dr. Schnee; from Pampán, Trujillo. Stamens not collected.

All of the specimens of the species in this group which were collected and studied by the Mission were identified as *Scheelea*. Male flowers were collected in all cases. The distribution of these palms is indicated in Figure 13. More detailed collections and studies will probably alter some of the ranges.

Coroba (*Scheelea macrolepis* Burret)

The *coroba* palm is found along the Orinoco River and its tributaries and is common from Puruy, Venezuela, near the mouth of the Caura River to El Rosario on the Cuchivero River and beyond Caicara on the Orinoco. The palms grow in dense pure stands known as *corobales* (Figure 14) and are found at the edge of tropical forests bordering savannah or grassland. The palms occur most commonly in sandy, relatively dry soil. Many of the *corobales* observed by the Mission had been burned several times but the palms appear to have recovered from the fire damage.

The identification of this species is difficult because it was originally described from male flowers only. The anthers of specimens collected by the Mission fit the description of this species perfectly. *Scheelea passargei* Burret was described from the Orinoco region on the basis of fruit only and it is quite possible that it is the same species as *S. macrolepis*. Fresh mature fruits

Figure 14. Dense stand of *coroba* palms (*Scheelea macrolepis* Burret), *llanos* south of Caicara, Bolívar.

Figure 15. Heavily fruited immature *coroba* palm (*Scheelea macrolepis*).

were not available when this region was visited by the Mission. The common name, *coroba*[24] has been misapplied to *Jessenia bataua*, which is known as *seje*.

The *coroba* palm averages about 9 meters in height but sometimes attains a height of 12 meters or more. In young trees the bases of broken leaves remain attached to the trunk, but taller and older trees have smooth gray trunks. The trunks average about 30 centimeters in diameter. The pinnate leaves are about 5 to 6 meters in length and about 2 meters in width. The largest leaflets measure 1.25 meters long and 5 centimeters wide. The linear leaflets are sessile, spreading, flat, and with an uneven apex. The upper surface is a silvery glaucous-green and the lower surface lighter, giving the palms a distinctive gray-green appearance. The female flowers are borne in erect green spathes and the staminate flowers are in separate spathes on the same tree. The woody spathes are more than a meter long and are channeled longitudinally. The bunches of fruit are erect when immature, but on maturing become pendulous with the increased weight (Figure 15). The fruit ripens from April to June and weighs from 5 to 15 kilograms, averaging nearly 10 kilograms a bunch. An immature bunch collected at Puruy by the Mission weighed 8.4 kilograms. (See Figure 16). The trees produce about three bunches of fruit a year and each fruit has one to three kernels.

While investigating the *coroba* palms found growing in isolated *corobales* south of the Orinoco in the vicinity of Caicara, members of the Mission several times encountered local inhabitants who were collecting fallen *coroba* fruit for home-processing into oil.

A man who was drying nuts preparatory to extraction of the oil consented to demonstrate how he did it. Although the process of producing *coroba*-kernel oil is carried out in the household by primitive methods, it differs very little in principle from that followed in a modern oilmill. The fruit is cut from the palm with a machete, knocked down with a pole, or picked from the ground. The outer pulp is eaten raw, boiled, or fried, or is fed to pigs. The fruit is dried in the sun for about two weeks, after which the shell is cracked between two stones. The separated kernels are cracked or broken in a *pilón* (cracking roll) made of wood and not unlike a large mortar and pestle. The broken kernels are heated in an iron bowl-shaped vessel (cooker) over a charcoal fire, being stirred to prevent burning. They are then passed through a household food-chopper which further grinds the kernels and starts the oil to flow (expeller press). The oily meal is transferred to another iron vessel where it is heated with water, also over a charcoal fire, until the oil separates and rises to the surface. The fresh oil is separated from the water and used for culinary purposes without further purification.

Figure 16. Typical bunch of fruit of the *coroba* palm.

People living in these isolated areas have little purchasing power and must necessarily conserve that little for the purchase of commodities they cannot produce themselves—manufactured tools, clothing, household utensils, etc. They must depend on the natural resources in their immediate environment for the production of edible fats. Commercial exploitation of the scattered *corobales*, especially in the vicinity of native villages or isolated dwellings, as a means of augmenting the national supply of fats does not appear practical from the standpoint of the present consumers: such exploitation could deprive them of their fat supply and increase the cost to a point where they could not buy it, thus reducing or destroying their present source of fats.

The *coroba* was the most abundant oil palm observed by the Mission in the Cuchivero River area. The area from Caicara to Cuchivero and El Rosario was surveyed along trails and roads and about 30,000 producing palms were observed. A number of *corobales* were measured and their size was found to average about 0.2 square kilometers (20 hectares). Most of the *corobales* consisted of dense, nearly pure stands of this palm. Many hectares contained 300 palms, each palm producing two bunches, or approximately 20 kilograms of fruit. This would equal 6,000 kilograms of fruit per hectare. A few were observed, however, with more than 1,000 palms per hectare. The *corobales* were scattered throughout the Cuchivero Valley, usually at considerable distances apart and there were no extensive stands.

On the basis of air surveys, a few aerial photographs, and ground surveys by jeep in the Caura and Cuchivero valleys, it was tentatively estimated that the region contains about 900,000 widely scattered producing palms. Assuming an annual yield of 30 kilograms of fruit per palm, it was estimated that about 2,700 metric tons of kernels, equivalent to about 1,600 metric tons of oil, are produced annually in the region.

Yagua or *Palma Yagua* (*Scheelea humboldtiana* Spruce)

Scheelea humboldtiana is found in the upper Orinoco Valley and its tributaries from the Caura River to its headwaters in the state of Amazonas. Specimens have been identified from Maroa, the mouth of the Vasiva River, the Caura River, Casiquiare River, upper Orinoco River, especially in the vicinity of the rapids at Maipures and Esmeralda, and the upper Río Negro. Along the Cuchivero this species was found between Santa Rosalía and Cuchivero.

The *yagua* is a tall palm bearing bunches of fruit measuring about 1.25 meters in length and weighing 20 to 25 kilograms. The individual fruit weighs from 25 to 30 grams and contains from one to three kernels. From three studies made in Venezuela, the weight of the pulp and outer husk was found to average 20 percent, the shell 71 percent, and the kernel about 9 percent of the total weight of the fruit.

People living in the Caura and Cuchivero River areas, said they do not use the *yagua* for food or oil because of its bad flavor.

A sample of *yagua* from the upper Orinoco, examined by Grünwald [25] yielded the following measurements: Average length of entire fruit, 5.1 centimeters; diameter, 3.2 centimeters; kernel, length 2.5 centimeters, diameter, 1 centimeter. Analysis of kernels: moisture 4.97 percent, oil 70.26 percent, ash 1.95 percent, protein 7.78 percent, fiber 10.80 percent, carbohydrates 0.04 percent.

The chemical and physical characteristics reported by Grünwald for this oil are given in Table 22. The fruit was partly decomposed and the pulp oil was in poor condition, which accounts for the high acid value observed. No accurate determination of the content of pulp oil could be made on this sample.

No separate estimates were made by the Mission of the potential yield of this species, which is included with other *Scheelea* and *seje* palms.

TABLE 22.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF *Yagua* KERNEL AND PULP OILS

Characteristics	Kernel	Pulp
Iodine value	17.0	70.7
Saponification value	242.6	178.8
Acid value	0.4	60.1
Esterification value	242.0	118.7
Color	White	Clear brown
Odor similar to:	Coconut oil	Butter
Consistency	Liquid	Solid

Figure 17. *Corozo* palm (*Scheelea excelsa* (?)) near the Yaracuy River, state of Yaracuy.

Corozo, Yagua, Palma de Vino (*Scheelea excelsa* Karst. (?))

Scheelea excelsa (?) was found most commonly in the tropical forests, but was also observed growing openly on cleared land. Individual trees are quite tall (Figure 17); one specimen felled by the Mission on the property of the Venezuelan Banana Company near the Yaracuy River measured 21.3 meters in height. The trunk was 9 meters from the ground to the base of the leaves. A single leaf measured 10.6 meters in length and the width of the pinnate blade at the center was 3.8 meters. The tallest specimens in the area were about 27 meters high. The brownish-gray trunk of the felled palm measured

35.6 centimeters in diameter. The large upright leaves were dark green and slightly drooping.

The species of this palm could not be definitely determined. The male flowers are typical of *Scheelea*. *Scheelea macrocarpa* was originally described from the Yaracuy River and *"Attalea speciosa"* has been recorded from this region, but present collections do not fit the former, and the latter name is of uncertain application. It is nearest to *Scheelea excelsa* and is being temporarily designated as this species. Probably more than one species of *Scheelea* occurs in this area.

Distribution and Yield. One of the greatest concentrations of *Scheelea* palms occurs in the area between Tucacas-San Felipe and Puerto Cabello. In the lowlands surrounding the Aroa and Yaracuy rivers these palms are found in large numbers. They are particularly concentrated in an area along the Aroa River and the Tucacas-Barquisimeto Railroad for a distance of 20 kilometers—between Kilometer 25 and Kilometer 45—and extending back from the railroad 5 kilometers on each side, comprising 20,000 hectares. This area was estimated by one Venezuelan author to contain 1,000,000 producing palms, with 590,000 more in the vicinity. The same author estimated that each palm bears four to six bunches of fruit. J. F. Stolk of Caracas estimated that there are 80,000 producing palms near the railroad in this area. He reckoned that the area contains 33 producing palms per hectare, with an annual production of 75 to 100 kilograms of fruit per tree. Another source estimated that each palm in this area produces 50 kilograms of fruit or a total of 25,000 metric tons. The average annual yield per producing palm observed by the Mission in this area was 1.2 bunches of fruit. The fruit matures between late January and May.

Figure 18. Fruit of *corozo* palm from a felled tree.

Several methods were employed by the Mission in surveying this area. Two observation flights were made and the boundaries of the palm area were outlined on detailed maps and airphoto mosaics. Aerial photographs were taken of a strip 18 kilometers long and 1.8 kilometers wide, containing 3,240 hectares. Several color photographs were taken of an area of 10 hectares. Counts of palms were made on the ground. Aerial observations indicated that an area of 600 square kilometers, or 60,000 hectares, contains oil-bearing palms. On the basis of the combined observations, it was calculated that about 50 percent of the area, or 30,000 hectares, has oil-bearing palms. Analysis of the airphotos showed a density of 25 palms per hectare; aerial color photos showed 21 to 26 palms per hectare, and limited ground surveys yielded 20 palms per hectare.

Stolk observed 33 palms per hectare in more extensive ground surveys. He calculated the average palm density at about 25 palms per hectare, or 750,000 palms in the area.

The Mission reckoned the annual yield per palm at 50 kilograms of fruit (1.25 bunches of 43 kilograms each), or 37,500 metric tons of fruit for the area. On the assumption that the fruit contains 14 percent of kernel this would be equivalent to 5,250 metric tons of kernels or 2,625 metric tons of oil per 30,000 hectares. This gives an oil yield of 87.5 kg./ha., compared with 400-600 kg./ha. for coconut palms in Venezuela.

Analysis of Fruit and Oil. This species of *Scheelea* palm bears bunches of fruit at the bases of leaves, usually about 5 to 9 meters above the ground, so that collection is difficult. Fruit can be reached from the ground only on young or low palms on cleared land. The Mission made a study of these palms in the Palma Sola area. Three bunches of fruit, collected on the holdings of the Venezuela Banana Company, weighed 42.4, 46.1, and 50.9 kilograms, averaging 46.5 kilograms. The heaviest bunch contained 48.4 kilograms or 95 percent of fruit (Figure 18) in the freshly cut, mature state. The average number of fruit on the bunches was 1,136, weighing 43.0 kilograms. The individual wet fruit varied in weight from 42.6 to 50.0 grams and the average dry weight (1,000 fruit) was 27.0 grams.

According to Marcel Monfils of the banana firm, a ripe freshly cut bunch of fruit he collected weighed 41.7 kilograms and yielded 2.5 kilograms of kernel oil, or 6 percent of the total weight of the bunch.

The fruit is elliptical in shape and is composed of outer husk, pulp, shell, and kernel. The weight-percentage distribution of the component parts, based on several samples of the fruit, is given in Table 23.

In the Palma Sola area it is estimated that one man can collect eight or ten bunches of fruit a day, equivalent to 20-25 kilograms of dried kernels or 11.5 to 14.5 kilograms of oil. It is said that one man can crack 1.83 kilograms of kernels an hour.

Stolk found that, by two pressings in a laboratory press, he was able to extract 60.8 percent of oil from the kernels. Available data on the oil content of these kernels are given in Table 24.

The kernel oil is white, semisolid, and similar to coconut oil in composition and uses. Some of its physical and chemical characteristics are presented in Table 25.

The sweet outer pulp of the fruit is eaten by monkeys, parrots, macaws, and other animals, which scatter the fruit. Samples collected by the Mission contained only 0.74 to 1.1 percent of oil in the outer pulp.

Table 23.—Weight-Percentage Distribution of Component Parts of *Corozo* Palm Fruit

Component	FAO Mission		Stolk	Grünwald[25]
	A	B		
Wet fruit, grams	....	42.6	49.1	38.2
Husk and pulp, percent	19.2	19.1	....	32.6
Shell, percent	62.6	64.0	....	55.2
Kernel, percent	18.2	17.0	10.0	12.2

[25] Number refers to literature cited at end of chapter.

Table 24.—Oil Content of *Corozo* Kernels

Source of data	Oil	Moisture
	(.....*Percent*.....)	
Venezuela	58.5	1.5
Venezuela	54.0	....
Venezuela	59.0	4.5
Venezuela	55.4	4.7
Grünwald	50.4	....
N. Y. Laboratory	58.8	2.5
Mission, Sample A	56.6	18.6
Mission, Sample B	66.2	7.7
Average	57.4	....

Coroba (*Scheelea macrocarpa* Karst.)

Scheelea macrocarpa was originally described from the Yaracuy and Tuy Rivers. Specimens collected from La Fría, Táchira state, appear to be this species. The *coroba* has been identified in all previous botanical studies as *"Attalea speciosa,"* but the anthers of specimens collected by the Mission were definitely *Scheelea* type. The palms are about 10 to 15 meters high and have a trunk 50 to 60 centimeters in diameter. The leaves are about 8 meters long and the blade is about 2 meters wide. Old leaves are persistent at the base, so that the palm presents a stocky rough appearance.

Distribution and Yield. Coroba palms grow in extensive stands south of Lake Maracaibo and along the railroad and Zulia River near the Colombian border. This area was surveyed from the air by the Mission. The palms are most

Table 25.—Physical and Chemical Characteristics of *Corozo*-Kernel Oil

Characteristics	FAO Mission[1]		M.A.L.[2]	Grünwald[3]
	A	B		
Refractive index, $n\,\frac{40^\circ}{D}$	1.4500	1.4489	1.4547	.....
Iodine value	11.63	19.30	15.4	15.9
Saponification value	248.5	244.7	238.0	248.7
Unsaponifiable matter, percent	3.68	.....	.....	.....
Reichert-Meissl value	6.93	6.98	6.8	.....
Polenske value	14.37	12.27	10.2	.....
Free fatty acids, percent (lauric)	0.28	0.08	.....	2.0
Melting point, °C.	24.2–24.5	.....	.....	.....

[1] Samples collected on the property of the Venezuelan Banana Co.
[2] Ministry of Agriculture and Livestock.
[3] Ref. 25. Sample of *palma de vino* from Taria.

Figure 19. Man on a ladder cuts fruit from a *coroba* palm (*Scheelea macrocarpa*) near La Fría, Táchira.

concentrated along the railroad —which, following the custom of the region, has kilometer markers along the right of way—from about 40 kilometers south of Encontrados to La Fría at Kilometer 105. Aerial photographs were taken of the area from the markers Kilometer 50 to Kilometer 60. The photographed area covered 45.3 square kilometers. Approximately 70 percent of the area contained about 35 palms per hectare. A total of 113,250 palms were counted or estimated in the airphotos. By aerial observation about 10 to 30 percent of the area from Kilometer 20 to Kilometer 50 was covered with *coroba, seje* (?), and some *moriche* palms. From Kilometer 50 to Kilometer 80, the area contained nearly 50 percent palms, and from Kilometer 80 to Kilometer 105 they varied from about 60 percent of the area near Kilometer 100 to about 35 percent near Kilometer 80. Fewer palms were observed toward Táchira. The palms are in the lowland valley area of the Zulia River and extend 10 to 15 kilometers along each side of the river and railroad. A specimen of *coroba* was collected at La Fría. Flying north from La Fría 30 kilometers along the railroad, directly northeast to San Carlos, and east to Garcitas very few oil-bearing palms were observed, but there were large numbers of *palma redonda (Copernicia tectorum)* and *moriche* palms along the rivers.

A preliminary estimate of the number of oil-bearing palms in this region, based on aerial observation and aerial photographs, is given in Table 26. The total number of producing palms is tentatively estimated to be about 1,515,000 in an area of 44,250 hectares. Stolk estimated about 6,000,000 palms in 20,000 hectares and Revete estimated about 2,000,000 palms in the area between Kilometers 60 and 80.

The annual yield of fruit per palm was not determined by the Mission but it was stated to be 100 kilograms. If this yield can be considered

Table 26.—Estimate of Oil-Bearing Palms in the Catatumba River—La Fría Area

Map location	Area			Palms	
	Total	With palms	With palms	Per hectare	Total
Encontrados to Táchira	*(Ha.)*	*(Percent)*	*(Ha.)*		
Km. 0–20	.....	..	.....	..	Few
Km. 20–40	.....	..	.....	..	Few
Km. 40–50	15,000	50	7,500	15	112,500
Km. 50–60	15,000	60	9,000	30	270,000
Km. 60–80	30,000	50	15,000	50	750,000
Km. 80–90	15,000	35	5,250	30	157,500
Km. 90–100	15,000	50	7,500	5	225,000
Km. 105–120	.....	..	.....	..	Few
Táchira to Colón	.....	..	.....	..	Few
			44,250		1,515,000

TABLE 27.—WEIGHTS AND MEASUREMENTS OF *Coroba* FRUIT FROM LA FRÍA

Component	Range	Average	Number of specimens
Ripe fruit and bracts, *grams*	65–83	78.5	10
Ripe fruit, *grams*	61–90	73.0	26
Immature fruit and bracts, *grams*	60–82	69.5	4
Immature fruit and bracts, *grams*	.....	72.7	1,114
Nut (shell and kernel), *grams*	27–56	35.0	13
Ripe fruit and bracts, length, *mm.*	56–65	62.6	10
Ripe fruit and bracts, width, *mm.*	41–49	46.7	10
Ripe fruit, length, *mm.*	50–58	54.0	26
Ripe fruit, width, *mm.*	43–49	46.5	26
Immature fruit and bracts, length, *mm.*	58–61	59.0	4
Immature fruit and bracts, width, *mm.*	42–47	44.0	4
Inner bracts, *mm.*	.....	32.0	.....
Outer bracts, *mm.*	.....	25.0	.....
Rostrum (beak), *mm.*	.....	9	.....

TABLE 28.—MOISTURE AND OIL CONTENT OF *Coroba* FRUIT FROM LA FRÍA

Component	Whole fruit	Moisture	Oil
	(.....*Percent*.....)		
Pericarp, ripe	27.5	12.3	30.4
Pericarp, immature	21.3	12.2	0.8
Kernel, ripe	5.0	15.1	55.4
Kernel, immature	8.5	22.4	45.4
Shell, ripe	67.5	....	....
Shell, immature	70.1	....	....

TABLE 29.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF KERNEL AND PERICARP OIL OF *Coroba* FRUIT FROM LA FRÍA[1]

Characteristics	Kernel oil		Pericarp oil
	Mature	Green	
Refractive index, $n_D^{40^\circ}$	1.4513	1.4512	1.4600
Iodine value	19.5	19.85	73.65
Saponification value	245.7	246.4	194.0
Unsaponifiable matter, percent	3.78	.....	.....
Reichert-Meissl value	6.05	5.72	0.44
Polenske value	15.55	9.77	2.87
Free fatty acids, percent (lauric)	0.16	0.3	[2]18.9
Melting point, °C.	21–22	24.0	.....

[1] Analysis made at the Southern Regional Research Laboratory, New Orleans, U. S. A.
[2] Calculated as palmitic acid.

accurate, the area would contain about 150,000 metric tons of fruit, equivalent to 7,500 metric tons of kernels, or 3,750 metric tons of kernel oil on the basis of the analysis of one specimen of fruit from the vicinity of La Fría. The amount of pulp oil is estimated to be about 10,000 tons. These figures, if creditable, would correspond to 84.7 kg./ha. of kernel oil and 226 kg./ha. of pericarp or pulp oil.

Analysis of Fruit and Oil. *Coroba* palms in the Encontrados-Táchira area produced an average of slightly more than one bunch of fruit per palm. One *coroba* palm growing in the open on a farm near La Fría was examined by the Mission. It was 8 meters high and bore eight bunches of fruit (Figure 19). On that date, 30 January 1948, one bunch was nearly mature while the remaining bunches were somewhat immature. A slightly immature bunch (Figures 20 and 21) weighed 85 kilograms and contained 1,114 fruits weighing 81 kilograms. On this basis the palm bore at least 650 kilograms of fruit at one time. Such a yield could not be expected, however, from similar palms growing in a wild state. Although the fruit collected from this tree cannot be considered entirely representative of other specimens growing in a wild state, considerable information was gained from examination of it, as shown in Tables 27-29.

The kernel oil of this palm is similar to coconut oil and has the same uses, whereas the pericarp oil is similar to African palm oil and can be used for the same purposes.

Figure 20. Bunch of *coroba* (*Scheelea macrocarpa*) fruit collected near La Fría, Táchira.

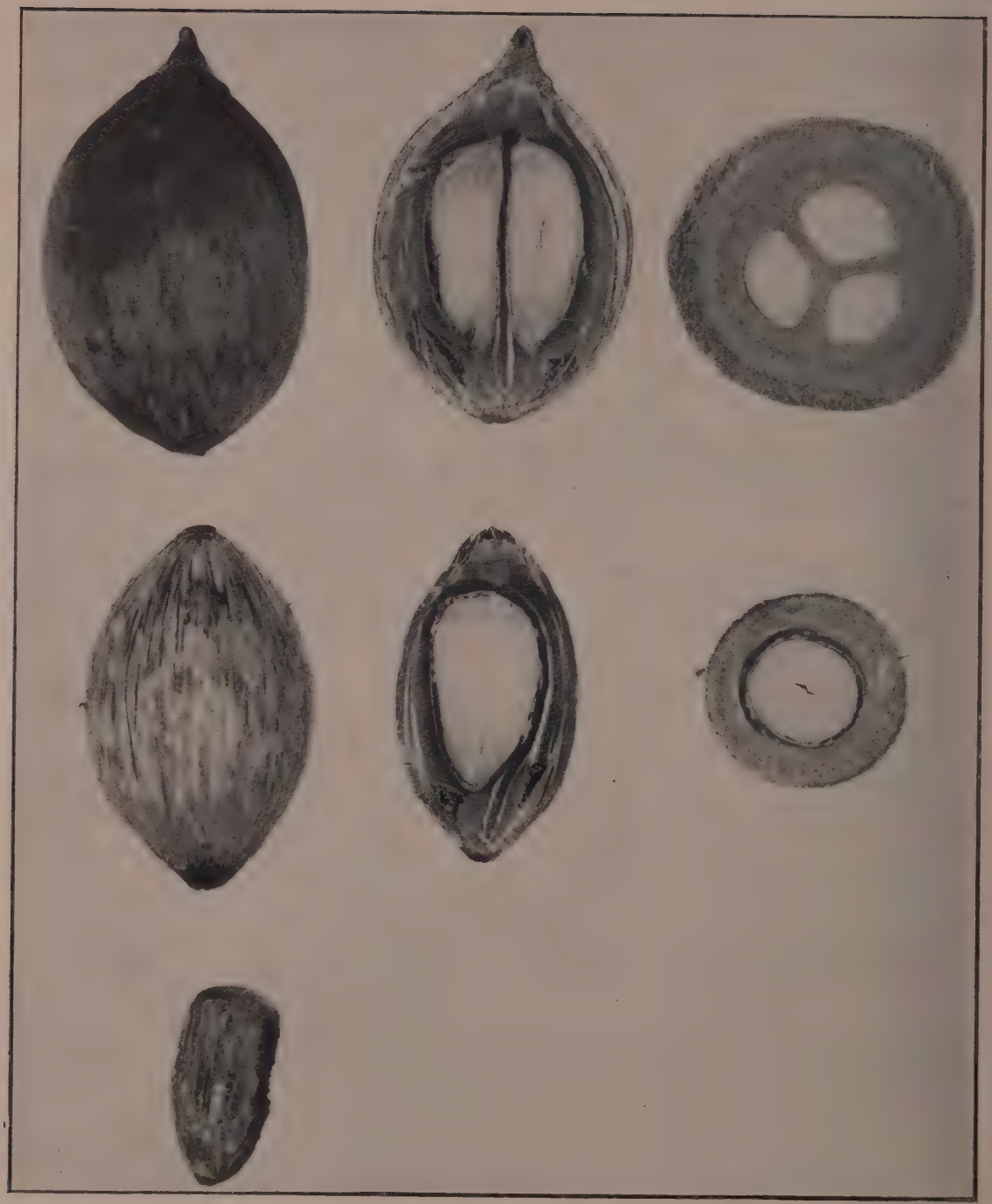


Figure 21. Individual fruit (natural size) of *coroba* from the specimen shown in Figure 20.

Figure 22. Distribution of *palma de leche, seje,* (*Jessenia*) and *temiche* (*Manicaria*) palms in Venezuela.

Seje (*Jessenia bataua* (Mart.) Burret)

The genus *Jessenia* was formerly considered part of the genus *Oenocarpus*. Two species of *Jessenia* are known in Venezuela, *seje* (*J. bataua*) and *palma de leche* (*J. repanda*). The distribution of *Jessenia* palms as known at present is shown on the map, Figure 22.

J. bataua is the most important species of *seje* palm in Venezuela. It is common along the Orinoco River and Gulf of Paria. *J. polycarpa* is

considered synonymous with *J. bataua*. The common name, *coroba*, applied to this species in Venezuela by Pittier and others [26] is a misnomer which applies to *Scheelea macrolepis*. The name, *seje*, is widely used and recognized by nearly all the inhabitants. *Seje* was studied by the Mission along the Caura, Cuchivero, and Orinoco rivers and at Cachipo, state of Monagas.

Palma de leche (Jessenia repanda) was observed by the Mission in the Catatumbo River

Figure 23. *Seje* palm (*Jessenia bataua*) Puruy, Bolívar.

area near La Fría and Táchira. Local residents use the fruit for food.

Distribution and Yield. The *seje* palm grows in tropical forests, especially in the humid forests along the upper Orinoco and its tributaries. It was not observed in arid or open areas. These palms occur singly or in scattered groups in the forest, reaching a height of 12 to 15 meters (Figure 23). The trunk is cylindrical, smooth and spineless, grayish-green in color, and from 20 to 30 centimeters in diameter. The leaves are pinnate and usually about 5 meters long. The drooping leaflets are about 1 meter long, about 10 centimeters in breadth, and are pointed at the tip. The bases of the leaves are clasping and surround the trunk. The base of the leaf crown resembles that of the royal palm. The inflorescence has a short peduncle and is found below the leaves. The spadix is about 1 meter long and the fruit is carried on the many hanging branches. The woody spathes are 1.5 meters in length. The flowers are monoecious. Usually one but sometimes two bunches of fruit is produced per tree per year.

The bunches of fruit weigh from 8 to 35 kilograms, and, on the basis of five analyses, average 20 kilograms. The fruit weighs approximately 14 kilograms, or about 70 percent of the weight of the bunch, the remainder being branches and the peduncle of the bunch.

The fruit varies in size in different areas, and each type has a distinctive common name. *Seje grande* or *seje toruno* is the most abundant type, especially near Puerto Ayacucho and the Sipapo River. It is most commonly found in mountain valleys. The purple fruit, which is about 4 centimeters long, ripens from April to November, but principally in July. *Seje pequeño* is an abundant type found in lowland forests, often in sandy soil. It occurs commonly near the Sipapo and Sanariapo rivers and other lowland areas in the upper Orinoco region. The fruit averages about 2 centimeters long. In the Amazonas area, the fruit measures 17 to 22 millimeters in length and 10 to 12 millimeters in width, and is purple when ripe. A type reported from Puerto Ayacucho measured 15 millimeters long and 11 millimeters wide, weighed 1.9 grams, and was reddish-green with white spots. The fruit ripens from April to June.

Data on the occurrence of *seje* palms along the Orinoco near the Sanariapo River, based on a survey made by H. E. Gonzales-Gragirena, are given in Table 30.

The extent of the areas and unit densities were estimated and the total number of palms was calculated. On the basis of the weights of 3 bunches of fruit, each palm produces 13 kilograms of fruit per season, a factor used to calculate the probable yield of fruit in each area.

Analysis of Fruit and Oil. In forested areas near Puruy the Mission observed about 40 *seje* palms to the hectare. Most of these palms bore two immature bunches of fruit which ripen in

TABLE 30.—DISTRIBUTION OF *Seje* PALMS ALONG THE UPPER ORINOCO NEAR SANARIAPO RIVER

Locality	Area	Palms			Yield of Fruit
		Per ha.	Total	Bearing	
	Ha.				*Kg.*
Paloma	150	150	22,500	12,657	164,541
La Boca	40	100	4,000	2,250	29,250
Costa Orinoco	1,250	75	93,750	52,735	685,555
Santa Inés	5	100	500	375	4,875
Aragustos	3	100	300	225	2,925
Santa Rosa	40	100	4,000	2,250	29,250
Chicle Malo	100	150	15,000	8,438	109,794
Tierra Blanca y Tonina	600	50	30,000	16,875	219,375
Cerro Pelota	300	100	30,000	16,875	219,375
Desecho Pelota	100	100	10,000	5,650	73,450
TOTAL	2,588	102.5 av.	210,050	118,330	1,538,390

May and June. The people of the region gather much of the available fruit when it is mature and boil the pericarp with water to separate the oil, which is used for cooking. It is probable that most of the palm fruit in the immediate area of the towns and roads is consumed in this manner. The fruit is obtained by climbing the trees or occasionally by cutting them down, if the leaves are needed to thatch houses.

Seje palm fruit contains both pulp and kernel oil, but the quantity of kernel oil is too small for consideration (0.3 to 1.1 percent). Pulp oil from the outer pericarp represents about 11 percent of the total weight of the fruit. The oil content of the outer pulp has been reported to vary from 22.2 to 49.4 percent, depending on the moisture content.

The yellowish-green pulp oil is said to be similar to olive oil and to be an excellent edible and cooking oil. The characteristics of this oil are presented in Table 31. According to Jamieson and McKinney,[27] it contains the following acids: oleic 76.5 percent, linoleic 3.4 percent, palmitic 8.8 percent, stearic 5.6 percent, triacontanoic 0.07 percent. This oil is known under many names including *segen, seje, patauá, bataua, coumou,* and *unamo.*

Cucurito, Cocorito (Maximiliana)

Maximiliana palms rather resemble *Scheelea* and related genera. The three petals of the male flowers are quite small and the six elongate anthers, which are not coiled, usually extend considerably beyond them. The four species found in Venezuela are *M. caribaea, M. regia, M. elegans,* and *M. macropetala.*

M. caribaea was described from the Island of St. Kitts and is common in Trinidad. It has not been previously reported from Venezuela, but the Mission found it to be common around the Gulf of Paria, and specimens were collected at Cachipo, state of Monagas.

M. elegans was collected by the Mission in

TABLE 31.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF *Seje* PALM OIL (*Jessenia Bataua*)

Characteristics	Venezuela (Venezuelan laboratory)	Orinoco River[28] (*Oenocarpus bataua*)	Colombia[29] (*Jessenia polycarpa*)	Brazil[27] (*Oenocarpus bataua*)
Specific gravity	0.9112–0.917	0.9248 (15°)	0.9161 (15°)	0.9118 (25°)
Refractive index, 25°C.	1.465–1.467	1.4691	1.4682 (20°)	1.4662
Solidification point, °C.	13.0	—9	.....	—5 to —9
Acid value	.....	1.40	.....	3.01
Free fatty acid, percent oleic	0.7–1.9	0.48	.....	.....
Saponification value	191.0–199.0	190.5	190	190.4
Reichert-Meissl value	0.15–0.44	.....	.....	0.33
Polenske value	0.2–0.5	.....	.....	0.19
Iodine value	74.5–83.8	80.0	74	75.4
Thiocyanogen value	73.3	.....	.....	72.8
Unsaponifiable matter, percent	0.4	0.76	.....	0.48

[27, 28, 29] Refer to literature cited at end of chapter.

Figure 24. Distribution of *cucurito* palms (*Maximiliana*) in Venezuela.

the Cuchivero River area near Rosalía. It was previously reported from Lower Guiana, near the Orinoco. In Colombia it is common in the *llanos*.

M. macropetala is a distinctive species described from Rosalía, Venezuela, and has not been reported elsewhere. It was not collected by the Mission.

M. regia is the most common name used in identifications of palms of this genus in herbaria. It is reported throughout the valley of the Orinoco and several of its tributaries. Its taxo-

nomic identity has not been checked, however, since it was not found by the Mission.

Distribution and Yield. The distribution of the various species of *cucurito* are shown on the map, Figure 24. They are common in the eastern part of Venezuela, but may occur farther westward. The main areas of occurrence are in the upper Orinoco and its tributaries. Large numbers are found in the vicinity of the Gulf of Paria. These palms usually grow in the hills and mountains, but they also occur in the same habitats as *Scheelea macrolepis*. Around Cachipo, *M. caribaea* commonly grows in forested areas along with *seje* and other palms, both in swamp land and in slightly elevated dry and sandy soil. They are quite hardy, even withstanding fires.

Cucurito palm species are quite similar in habit but differ in flowers, spathes, and fruit. These spineless palms range from 8 to 15 meters in height and have a grayish trunk 25 to 30 centimeters in diameter. The pinnate leaves are about 8 meters long, fibrous at the base, and have large dark leaflets grouped along the leaf midrib.

The deeply ribbed, pubescent spathes are quite large, measuring two meters in length. The apical beak of the spathes of *M. caribaea* is 53 centimeters long, while in *M. elegans* it is only 35 centimeters long. The peduncle is about 60 centimeters in length, and 35 to 45 centimeters in width at the widest point. The spadix branches average 10 centimeters long and bear a few female flowers at their base or are entirely staminate.

Each *cucurito* palm produces two to three bunches of fruit a year. The bunches average 17 to 20 kilograms each, with a maximum of 40 kilograms. They are larger than those of *Scheelea macrolepis*, but the individual fruits are smaller.

The fruits of the palms referred to as *M. regia* and *M. elegans* mature from April to October with the maximum ripening from May to July in the upper Orinoco and Cuchivero River areas, and in British Guiana. The harvest season for *M. caribaea* in the area of Irapa, Gulf of Paria, is from January to July.

Air reconnaissance was made of general areas of *cucurito* stands and a few airphotos were taken but no reliable estimates of yields could be made. It is difficult to distinguish *cucurito* from species of *Scheelea* in airphotos, and undoubtedly many *cucurito* have been included in the estimated yields of *Scheelea*. More detailed surveys should be made of the widely scattered *cucurito* stands in Venezuela.

TABLE 32.—COMPOSITION OF PULP AND KERNEL OF *Cucurito* PALM FRUIT[25]

Constituent	Pulp	Kernel
	(*Percent*)	
Moisture	26.30	12.11
Ash	3.40	1.99
Protein	5.51	8.45
Fat	42.09	57.55
Crude fiber	9.15	19.90
Carbohydrates	13.55	.....

[25] Number refers to literature cited at end of chapter.

It has been estimated that in British Guiana an area of 232 square kilometers (23,200 ha.) contains 1,023,570 *M. regia* palms, or an average of about 44 palms per hectare along several rivers. Half of these palms (511,785) were estimated to produce fruit (20 kg. per palm) containing 10 percent oil—about 1,023 metric tons of oil, or approximately 44 kg./ha. A survey of *M. caribaea* was made in Trinidad, resulting in an estimate that 31,000 hectares contained palms producing about 300,000 bunches of fruit, equivalent to 10,000 tons of fruit or 1,000 metric tons of oil. The yield was at the approximate rate of 32.2 kg./ha.

Analysis of Fruit and Oil. The fruit of the *cucurito* palm measures 3.75 to 5.0 centimeters in length and 2.0 to 2.5 centimeters in diameter. It is round at the base and pointed at the apex; the shell measures about 3.0 centimeters in length and 1.3 centimeters in diameter. The one to three (usually one) kernels are 1.0 to 1.5 centimeters in length. Grünwald [25] reported the average weight of 100 fruits from the upper Orinoco to be 7.5 grams. The pulp and outer husk comprised 44.7 percent, the nut 45.6, and the kernel 7.7 percent of the whole fruit (see Table 32).

Cucurito palms produce fruit containing both kernel and pulp oils. The inhabitants near Caicara, Rosario, Cuchivero, and Cachipo all said that *cucurito* is not used locally as a source of edible oil or for other edible purposes because the pulp oil quickly spoils and becomes rancid. These observations are borne out by the high free fatty acid content of the pulp oil from the upper Orinoco and other areas. The characteristics of the kernel oil are presented in Table 33. A sample from Trinidad was identified by Collin [30] as *M. caribaea* and was stated to be immature. This is borne out by the low fat content (4.8 percent) of the kernel and the high iodine value, 22.7. In-

Figure 25. *Corozo* palm (*Acrocomia ierensis*) near Cachipo, Monagas.

sufficient fat was available for a complete determination of the fatty acids. A rough fractionation of the derived esters indicated the approximate presence of 5 percent capric, 47 percent lauric, 21 percent myristic, 9 percent palmitic, and 18 percent unsaturated acids.

TABLE 33.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF *Cucurito* KERNEL OIL

Characteristics	Upper Orinoco[25]	Trinidad[30]	British Guiana[31]
Specific gravity, $d_{15°}^{100°}$	.....	0.8673	.....
Iodine value	7.8	10.5	22.7
Saponification value	243.0	248.5	236.8
Unsaponifiable matter, percent	.....	0.3	0.23
Acid value	12.6	2.6	20.2
Reichert-Meissl value	.....	3.0	.....
Polenske value	.....	7.0	.....
Melting point, °C.	.....	28.2	.....

[25, 30, 31] Numbers refer to literature cited at end of chapter.

TABLE 34.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF *Cucurito* PULP OIL

Characteristics	Upper Orinoco[25]	British Guiana[31]
Iodine value	84.0	51.4
Saponification value	197.9	211.6
Acid value	109.1	.....
Solidification point, °C.	.....	25.5
Esterification value	88.8	.....

[25, 31] Numbers refer to literature cited at end of chapter.

Pulp oil obtained from a sample of *cucurito* taken in the upper Orinoco region was stated by Grünwald [25] to be a dark brown solid, while that from British Guiana [31] was described as a semisolid, orange-red fat; it is probably a different species. The physical and chemical characteristics of these two pulp oils are given in Table 34.

Corozo (*Acrocomia*)

Corozo palms are widely distributed and fairly common in the extensive *llanos* and other relatively dry areas of Venezuela (see map, page 27). They are usually scattered and rarely found in great density over wide areas. The fruit is spherical in shape and both the mucilaginous pulp and the kernel contain oil.

These spiny palms are usually 5 to 8 meters in height and have gray trunks which are often slightly swollen in the middle. The trunk has rings of dark brown spines 2 to 12 centimeters in length. The leaves are about 3½ meters long, and have relatively narrow hanging leaflets. The spathes are about 1.5 meters in length and 20 centimeters in diameter. They are covered with a light brown close, feltlike layer of hairs and often have a few spines 2 centimeters long. The spathes are smooth and dark brown on the inside.

While recognition of palms belonging to the genus *Acrocomia* is not difficult, identification of the species in Venezuela is extremely so. Up to the present, all specimens have been referred to *A. lasiospatha* and *A. sclerocarpa*. The former was described from French Guiana and is not well understood. The latter cannot be identified among any living material, according to Bailey,[32] and its status is not certain even though many botanists and others have applied the name *Acrocomia* to *sclerocarpa* palms throughout the American tropics. Specimens (Figures 25 and 26) collected by the Mission at Cachipo, Venezuela, com-

pare very closely to *A. ierensis* Bailey from Trinidad, except that the fruit is larger, with a less sharply pointed involucral base. The fruit of *A. ierensis* generally measures not more than 3.8 centimeters in diameter. Specimens reported from Bolívar, Roscio District, measured 4.9 by 4.7 centimeters and from Guasipati, 4.3 by 4.14 centimeters; they appear to be a larger-fruited undescribed form. Fruit from Paragua, Bolívar, are similar in size but have different leaf characters. It appears that the *Acrocomia* species of Venezuela are not well understood and are not clearly identifiable with the material available for comparison.

Distribution and Yield. These palms are usually found in the higher *llanos* at elevations from 200 to 1,000 meters. They are less common in the flooded river valleys and are not abundant at elevations above 1,000 meters. The distribution and relative abundance, compiled from the Mission survey and from other available sources, are summarized as follows:

Anzoátegui—Aragua de Barcelona to Ciudad Bolívar along road, 28 km. wide, estimated 40,000 to 150,000 tons (scattered). In Guanta, 25,000 producing palms in 291 hectares (88 per hectare); Barcelona.

Apure—Scattered.

Barinas—(Zamora) Barinas to Puerto Nutrias, 800,000 hectares, solid stand, 50 to 60 palms per hectare. Another estimate, 10,000 palms at 45 kg. per tree per year. From Puerto Nutrias to Catalina very abundant. At La Libertad some exploitation.

Bolívar—Guasipati, concentrations from El Palmar, El Pilar, Miamo, and from San Felipe La Tigra to San Ramón; scattered at Machiques and Puruy, Caura River area, Cuchivero, Cuchivero River, El Paragua, Roscio District.

Cajedes—Scattered.

Carabobo—Carlos Arvelo District.

Falcón—Lower Toruya.

Guárico—Pascua Valley to Pariaguán, scattered along road; Calabozo south along Guárico River in *llanos*, 10,000 palms on one ranch.

Lara—Torres District.

Miranda—Scattered, Las Mercedes to El Sombrero.

Monagas—Maturín and Caripito, along roads; Cachipo.

Portuguesa—Scattered in *llanos*.

Sucre—Marino District, Lacanella, Campo Clara, Cumaná.

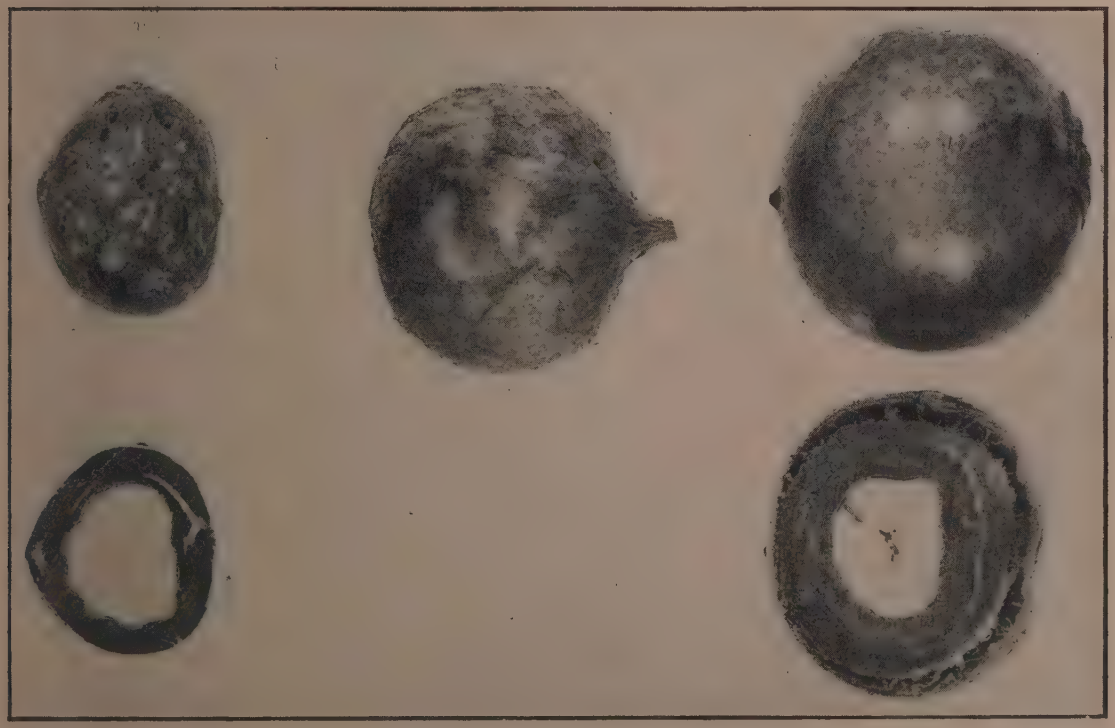


Figure 26. Fruit (natural size) from *corozo* palm in Figure 25.

TABLE 35.—MEASUREMENTS OF *Corozo* FRUIT REPORTED FROM DIFFERENT LOCALITIES IN VENEZUELA

Locality	Length	Diameter	Weight
	(...*Centimeters*...)		(*Grams*)
Guasipati	4.3	4.1	15
Cachipo	...	...	35
Yaracuy	4.9	4.7	15
Lara	...	...	20
Trinidad	3.8	4.4	30

TABLE 36.—PERCENTAGES OF HUSK, PULP, SHELL, AND KERNEL OF *Corozo* FRUIT FROM DIFFERENT LOCALITIES

Component	Cachipo[1]	Guasipati[2]	Trinidad
Husk	20.6	26.3	59.7
Pulp	24.9	63.2	
Shell	42.4		31.3
Kernel	12.1	10.5	9.0

[1] Collected by Mission.
[2] Ministry of Agriculture and Livestock; specimen collected 15 July 1947.

Táchira—San Camilo Mountain, Caparro and Dorado rivers to state of Barinas.

Trujillo—Between Meme Grande and Cuicas, 4 sq. km., 12,000 palms.

Yaracuy—San Felipe and San Javier.

Zulia—In mountainous section of Maracaibo area (400 sq. km. (?)), scattered, a few near Encontrados.

The average mature *corozo* palm was observed to produce about seven bunches of fruit a year, but production varies in the different regions. Four to five bunches were observed in Bolívar, seven in Monagas, and ten are reported in Lara and Carabobo. Two average-sized, almost mature bunches, 70 centimeters long and 30 centimeters in diameter, were weighed at Cachipo by the Mission on 1 February 1948. The bunches weighed 7.5 and 11.6 kilograms and contained 190 and 323 fruits. Others reported an average of 200 fruits per bunch.

The palms begin to bear at the age of four years. Six months is required for the fruit to mature, according to a Venezuelan report. Immature but full-sized specimens were collected in the Cachipo area by the Mission on 1 February 1948. Fruit ripens in this area from late February to May. Near Cuchivero it is said to mature from January to March, but no maturing fruit was observed in this area by the Mission. Ripe fruit has been collected in June and July at Guasipati, and in August at Falcón. In the Maracaibo area *corozo* fruit is marketed in March and April.

Analysis of Fruit and Oils. The almost spherical fruit has a thin fibrous cover underlain by a mucilaginous yellow pulp, which contains oil. Various measurements reported for *corozo* fruits from different localities are given in Table 35. The inner shell is thin (2 to 4 mm.), hard, and slightly brittle, and inside it is a single, nearly round kernel (Figure 26). The proportions of husk, pulp, shell, and kernel of different specimens of *corozo* are given in Table 36.

The hard white kernel contains a white to yellowish-white oil, in amounts varying from 44 to 55 percent, depending on the moisture content and source. The physical and chemical characteristics of this oil are given in Table 37.

The kernel contains an oil having physical and chemical characteristics similar to coconut oil and hence the same general uses. The most distinctive

TABLE 37.—PHYSICAL AND CHEMICAL CHARACTERISTICS OF *Acrocomia* KERNEL OILS FROM VARIOUS SOURCES

Characteristics	Venezuela[1]	Trinidad[2]	Central America[3]	West Indies, Brazil, and Paraguay[4]
Specific gravity	.....	0.861	0.9136	.....
Iodine value	.....	18.2	26.6	24.0
Saponification value	232.6	233.0	241.0	240
Acid value	3.7	.....	2.5	.....
Reichert-Meissl value	.....	7.2	5.0	6.0
Free fatty acids, percent	1.3	0.6	.....	.....
Melting point, °C	.....	25.0	25.0	25
Solidification point, °C	.....	.....	16.0	18

[1] Ministry of Agriculture and Livestock, 1947.
[2] Average of 2 analyses.
[3] Average of 3 analyses.
[4] Average of 18 analyses.

difference in the characteristics of this oil and those of coconut and *coroba* oils is its higher iodine value: *Acrocomia* 18-27, coconut 8-10, *coroba* 20. The saponification value (233-241) is lower than for coconut (251-263) and *coroba* oil (246, 2 samples only).

The fatty acid composition of the kernel oil of a specimen identified as *Acrocomia sclerocarpa* from Trinidad has been reported by Collin[30] as follows: Caprylic 7.8 percent, capric 5.6, lauric 44.9, myristic 13.4, palmitic 7.6, stearic 2.6, oleic 16.5, linoleic 1.6.

The press cake made by pressing a sample of kernels in the laboratory, which removed 44 percent of the oil, was analyzed as follows: Moisture 9.48 percent, ash 4.11, fat 20.45, crude fiber 11.36, protein 25.83, carbohydrates 28.77, calcium 0.21, phosphorus 0.98. This is reported by the Ministry of Agriculture and Livestock.

It has been stated that *Acrocomia* pulp contains about 30 percent oil; one Venezuelan report indicates 33 percent of pulp oil in the fruit. An immature sample collected by the Mission at Cachipo contained only 0.25 percent oil and 12.8 percent moisture. The pulp is said to have an agreeable sweet taste and is edible; it is consumed especially by livestock.

The average values for several physical and chemical characteristics of *Acrocomia* pulp oils for five samples of South American origin are: specific gravity 0.910, iodine value 66.9, saponification value 202.6, acid value 77.65, solidification point 6.7°C.

Temiche (*Manicaria saccifera*)

Temiche palm *(Manicaria saccifera)* is very abundant in the Delta region of the Orinoco. It is well known by the name *temiche* and is not confused by the inhabitants with other palms. It often occurs in pure stands known as *temichales.*

The trunk of the palm is ringed, usually erect, and may be 30 centimeters in diameter. The base of the trunk may be leaning, and there are often aerial roots at the base. The leaves are large and pinnate, but usually undissected, and may attain a length of 10 meters and a width of 2 meters. The leaves often end abruptly and appear saw-toothed. Male and female flowers are found on the same flower stalk, the female flowers being nearer the base of the stalk, where the fruits later develop.

Distribution and Yield. Distribution extends from the Gulf of Paria along the San Juan River and the mouth of the Manamo Channel *(Caño Manamo),* including much of the Orinoco Delta, south along the Amacuro River and into British Guiana. It is also reported in the upper Orinoco in the La Boca area near Sanariapo and the upper Río Negro, but these occurrences were not confirmed. Samples have been collected from near Guanaco, Manoa, Caripito, and Monago. It is possible that *Manicaria plukenettii,* which is the common species of Trinidad, may grow in the coastal delta area.

Large stands of *temiche* were observed from the air near Cojoida and Curiapo and along the lower Orinoco. The palms were easily distinguished by the yellowish-green, broad, undissected leaves in somewhat compact clusters. The palms sometimes form nearly pure stands, but they also accompany *seje* and *moriche* palms. They are abundant only in wet swampy land along the coast and rivers, in areas subject to considerable flooding. Distribution along the coast is probably correlated with the fact that the nut has a hollow center like a small coconut and can be carried by river and ocean currents.

The bunches of fruit are relatively small; in Panama it was observed that each bunch contained about 40 fruits weighing about 2.5 kilograms. The annual production per palm is small. Each palm produces an average of about four bunches, or a total of about 10 kilograms of fruit annually. The fruit without stalks was estimated to weigh 6 or 7 kilograms per palm.

A preliminary air reconnaissance was made in part of the Orinoco Delta, especially in the area of Curiapo. From the air, *temiche* palms are readily distinguished by their large yellow-green leaves and by the fact that they are not as tall as the other species, such as *seje* and *moriche. Temiche* usually occurs in clumps or groups, often near rivers or small streams, and in clearings. The palms are widely distributed and locally common, but very scattered or absent in many areas. No palms were identified at the village of Curiapo, but they are very abundant in an area about 5 kilometers east of this village. Analyses of airphotos confirmed the aerial observations. One hundred eleven photographs (Nos. 120 to 230) were taken in the Curiapo area; seven photographs (Nos. 217, 222, 228, 121, 127, 183, and 204) showed the greatest concentrations of *temiche* palms, but densities were only 15 to 30—averaging about 20—palms to the hectare. (These photographs, made for the Mission, are part of the permanent files of the National Cartography

Branch *(División de Cartografía Nacional.)*) *Temiche* palms are distinguished from *moriche* on aerial photographs by the rosette of large, elongate, white areas of the leaves. In stereoscopic analysis, these palms appear much shorter and have a different growth habit than that of *moriche*, which have many small clusters of fanlike leaves and are much more abundant and widespread than *temiche*.

Aerial photographs of the Orinoco Delta region cover 120 square kilometers, of which only about 3 percent (3.6 sq. km.) contains *temiche*. At an average density of 20 palms to the hectare, the 360 hectares would contain about 7,200 palms. A tentative estimate of 6 kilograms of fruit per palm would be equivalent to about 43,000 kilograms of fruit, or 6,000 kilograms of oil.

No reliable estimate could be made of the total amount of *temiche* in the entire delta, but it probably is quite high. However, the low density per unit area rules out any possibility of exploitation under present conditions.

Estimates of the total number of these palms in Venezuela and their yield are difficult to make. A local producer said that he could deliver 10,000 metric tons of *temiche* fruit in the Sacupana River region, and estimated that about 40,000 metric tons of *temiche* fruit could be collected in the Amacuro Delta area.

Fruit and Oil Analysis. The brown-colored fruit is more or less spherical, about 4.5 centimeters in diameter; its surface is quite rugged and covered with irregularly angled protuberances. The inner, dark-colored seed measures about 3 centimeters in diameter. The fruit is usually single, but occasionally double or triple fruits, 7 centimeters in diameter, are found.

No analysis of the fruit has been reported for specimens from Venezuela, but analyses of the same species growing in Panama were reported by Jenkins [1] in 1944. The wet weight of the whole mature fruit averaged 38 grams; the outer husk weighed 20 grams, or 47 percent of the total weight; the shell 6 grams, or 16 percent of the total weight; and the kernel 14 grams, or 37 percent of the total wet weight. The dried kernel and shell weighed from 10.0 to 16.4 grams.

Collin [30] reported that a sample of *Manicaria saccifera* nuts grown in Trinidad contained 15 percent of kernels having 57.7 percent of a coconut- or lauric-acid-type of fat. The characteristics of this fat are: Iodine value, 10.7; saponification value, 221.8; unsaponifiable matter, 0.05 percent; acid value, 0.6; melting point, 27.1°C. The fatty acid composition of the fat was: Caproic, trace; caprylic, 5.3 percent; capric, 6.6; lauric, 47.5; myristic, 18.9; palmitic, 8.2; stearic, 2.4; oleic, 9.7; and linoleic, 1.4.

The fruit is eaten by animals in the delta region; the water inside the fruit is drunk by local people, but it is diuretic.

Macanilla, Tucum, Cumare (Astrocaryum)

The genus *Astrocaryum* is represented in Venezuela by about six species. The trees are much smaller than *Scheelea* palms and the production of fruit is not so large. Of the species of *Astrocaryum* studied in Venezuela by the Mission, the following were considered to be the most important though not of potential commercial value:

Macanilla (A. jauari) occurs commonly along the Orinoco and its tributaries. Specimens were collected at Puruy and Caicara (Figures 27 and 28). This palm occurs in fairly large numbers and

TABLE 38.—SUMMARY OF DATA ON *Scheelea*-TYPE OIL PALMS

Region	Area	Estimated number of palms	Annual yield	Kernels	Oil
	Ha.		*Kg. per palm*	*(.....Metric tons.....)*	
Encontrados	90,000	1,500,000	100	15,000	3,750
Palma Sola	60,000	750,000	50	4,250	2,125
Cuchivero	(.....)	900,000	30	2,700	1,600
Bobures and Garcitas	50,000	500,000	50	2,500	1,250
Pto. Ayacucho (incl. *seje*)	(.....)	500,000	30	1,500	750
Sanariapo (*seje*)	2,588	210,000	....	[1]1,538	154
Barlovento	(.....)	100,000	50	500	250
		3,460,000			9,879

[1] Total weight of fruit.

is used locally. No detailed survey was made, since it was not considered economically important.

Macanilla or *tucum (A. tucuma)* has somewhat greater possibilities for exploration, but no extensive stands were observed. It is exploited somewhat in Brazil.

Macanilla or *cumare (A. vulgare)* was found at Puruy near the Caura River, at Caicara, and along the Cuchivero River. The fruit is larger than that of *A. jauari* and is used locally. The palms were not observed to be abundant enough for commercial exploitation.

Figure 27. *Macanilla* palm (*Astrocaryum jauri*), Puruy, Bolívar.

Possibilities for Commercial Exploitation

Wild oil-producing palms are present in large numbers in Venezuela, but many of the largest stands are in relatively inaccessible areas where commercial exploitation is not practicable. The palm areas surveyed by the Mission were confined principally to those in which transportation was available and where commercial exploitation might be considered feasible. Although large numbers of palms exist in many areas of Venezuela, those having potential commercial possibilities are few, considering the many and various production factors.

Coroba and *yagua (Scheelea)* types of wild oil palms were observed to be the most abundant and productive. Most of the surveys were made of these types of palms. Estimates of the number of producing palms were calculated on the basis of observations made during the survey and of all available data. Survey estimates are based on detailed surveys of small quadrat areas within larger areas. While the results probably give a reasonable representation of the total palms of certain areas, they must be considered tentative or preliminary. A summary of palm numbers and calculated oil yields is given in Table 38.

Since the Mission surveyed only areas of wild oil palms where transportation was available, no estimates were made of extensive palm stands in the upper Orinoco, Río Negro, and the headwaters of large tributaries of the Orinoco. Great numbers of scattered *corozo (Acrocomia)* and other types of palms were observed, but they did not appear to be present in sufficient concentration for commercial exploitation. Several extensive stands were observed, for example, in

Figure 28. Fruit of the *macanilla* palm.

Sucre state, but no estimates were made. It is estimated that about 10,000 metric tons of palm-kernel oil could be obtained under optimum conditions in Venezuela, which probably represents about 10 percent of the total amount of this type of oil.

Table 38 shows a probable yield of 9,879 metric tons of palm-kernel oil in an area of more than 202,600 hectares (the areas for Cuchivero and Barlovento are not given). This yield of oil corresponds to an average of 48.7 kg./ha. In limited areas, the yield might be twice as great as the average, or somewhere in the neighborhood of 100 kg./ha. These potential oil yields should be compared with those of cultivated oil-bearing crops, especially those now produced in Venezuela.

It has already been pointed out that the estimated yields of coconut oil in Venezuela vary from 395 to 600 kg./ha., and that the African oil palm, which has recently been introduced into Venezuela, produces under optimum conditions 2,000 to 3,000 kg./ha. of oil.

In the following chapter the average yield of sesame between 1941 and 1946 is shown to have been 682 kg./ha., equivalent to 341 to 375 kg./ha. of oil, and yields of 1,000 kg./ha. of sesame seed, equivalent to 500-550 kg./ha. of oil, have been obtained under ordinary farming conditions. Even cottonseed, which is a by-product of cotton lint, averages 41.5 kg./ha. (1941-1946) in addition to linters, meal, hulls, and cake.

Production Factors

Even though large numbers of high-yielding oil palms may be present in an area, the possibilities of their economic exploitation depend on a number of factors that require careful study. Before any exploitation is attempted, a detailed survey of the various factors in the particular area should be made.

Some of these factors are: (1) Density and yield of palms per unit area, (2) type of terrain and vegetation, (3) transportation within the area, and to and from oilmills, (4) labor supply, health, and living conditions, (5) market price and demand for oil, (6) availability or adaptability of machinery, (7) power and water supply, (8) use of available raw material by local people, (9) acceptability of the material by the crude oilmill, (10) over-all cost of production per unit volume of product at point of production and delivered to the oilmill.

With these factors in mind it is worth while to examine a potential producing area or two with respect to the feasibility of exploitation. For example, the Encontrados and Palma Sola regions have areas containing an average of 25 or 30 palms to the hectare and about 50 percent of the total area (150,000 ha.) contains palms having an estimated total production of 5,875 metric tons of oil. The average yield is 39.1 kg./ha. for the whole area, or 78.2 kg./ha. if the palms are considered to be concentrated in one-half (75,000 ha.) of the area. With a unit-area yield of such small magnitude, exploitation is obviously marginal at best.

Both regions have railroad and small-river transport, but distances from oil-milling centers other than Puerto Cabello are considerable, and transport and handling charges are extremely high.

In the Palma Sola area a local producer estimated that one man with good trails, adequate equipment, and good supervision could collect eight or ten bunches of fruit a day, which would yield 20 to 25 kilograms of dried kernels, or 10 to 12.5 kilograms of oil. Efficiency of available labor is low; the best workers have gone to the oilfields and cities. Wages are 8 to 10 bolívares a day for manual labor. In other words, the cost of collecting the raw material is equivalent to about 0.8 bolívar per kilogram of oil for common labor. It was also estimated that one man can produce 1.83 kilograms of kernels an hour by hand-cracking, which on the assumption of 50 percent oil content is equivalent to 0.92 kg./hr of oil. At the same wage rate, the cracking operation would cost 1.0 to 1.2 Bs per kilogram of oil or a total cost of approximately 2 Bs for the equivalent amount of raw material for one kilogram of oil, f.o.b. point of production.

These figures should be considered in the light of the farm price of sesame seed, which rose from 55.5 Bs per 100 kg. in 1941 to 70 Bs in 1945 and to 115 Bs in 1946. Sesame oil, however, is an exceedingly high-quality edible oil, whereas the principal outlet for palm-kernel oil is in the soap industry, which is normally the cheapest outlet for vegetable oil. Kernel oils do, however, find some market in the shortening field, where hydrogenated fats are unavailable for making blended shortenings.

Commercial exploitation of palm nuts requires cracking machines that are small enough to be transportable on river boats and strong enough to efficiently crack the palm fruit. So far no

completely satisfactory machine has been developed. A palm-nut cracking machine has been developed by J. F. Stolk of Caracas which appears to have some merit. A small working model of this machine is shown in Figures 29 and 30.

A test run made with this machine on a sample batch of *coroba* nuts was not very successful. Only 53 percent of the nuts were cracked on the first passage through the machine and only 70 percent on two passages. However, the efficiency could be greatly improved by classifying the nuts into two or three sizes before cracking and handling each size in a machine adjusted for that size.

Mechanical cracking of nuts is only part of the operation; another and more important part is the separation of kernels and shells. *Coroba* nuts used in the test contained 14.2 percent of kernels but in the first passage only 1.1 percent of the kernels were freed from their shells and on the second passage only 2.7 percent. The remaining kernels adhered tenaciously to the shell and could be removed by hand only with great difficulty.

The theory was advanced that it is not necessary to make a clean separation of shells and kernels for oil-milling purposes, but any experienced oilmill operator would refuse to accept the unseparated product. Adhering shells would make it difficult or impossible to crack or flake the kernels to the particle size requisite for extracting oil; the hard shells would ruin the faces of expensive rolls, destroy expensive press cloths used in hydraulic presses, produce excessive wear in expellers; and finally the shells present in the kernels would absorb oil, thereby reducing the yield.

It is evident, therefore, that not only must a cracking machine be developed but it must cleanly separate shells from kernels. In the absence of efficient cracking machines, reliance remains on the primitive method of manual cracking. This operation requires an abundant supply of cheap labor, which does not now exist in Venezuela.

Figure 29. Hopper and cracking discs of Stolk's palm-nut cracking machine.

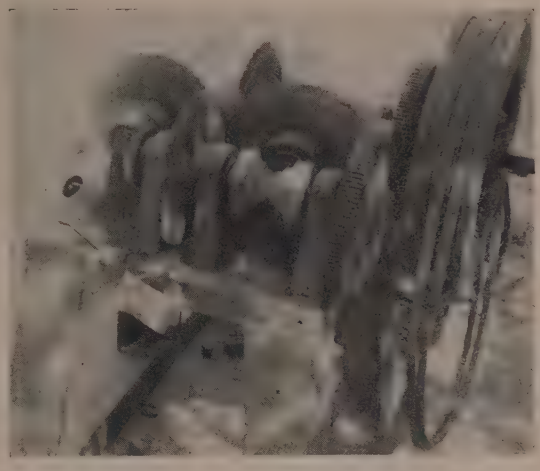


Figure. 30. Stolk's palm-nut cracking machine, hopper removed.

Conclusions

Coconut (Cocos nucifera). The Mission estimates that there are more than 1.5 million producing coconut palms in Venezuela. These trees can produce an annual oil yield of more than 9,000 metric tons, compared with trade estimates of 2,000 tons and government estimates of 6,600 tons. Government estimates indicate that the 6,600 tons of oil are produced on 16,700 hectares of land, making an average annual oil yield of 395 kg./ha. The coconut is thus the most prolific present source of vegetable oil in Venezuela.

Because of the economic importance of the coconut palm and its oil, the Government should undertake *immediately* a thorough and accurate census of the coconut palm and all of its products and end-uses. This census should include size of areas devoted to coconut palm culture, number of existing palms, number of bearing palms, relative age, incidence of disease and insect infestation, annual yield of fruit, market disposition, copra and oil production, end-uses of the oil (soap, shortening, etc.).

On the basis of this information, steps should be taken to increase coconut cultivation in areas adapted to its growth, which need not be confined, as at present, principally to coastal areas; the coconut does equally well in many interior areas. Steps should be taken to control insects and diseases and to improve cultural practices, including the use of fertilizers to stimulate greater yields.

African Oil Palm (Elaeis guineensis). This palm, recently introduced into Venezuela, has been proved in other parts of the world to produce the largest yields of oil per hectare of any vegetable-oil crop. This is a very important consideration in Venezuela, where costs are high and there is a relatively small amount of available fertile agricultural land.

One of the main recommendations of the Mission is that the African oil palm be planted on a large scale in Venezuela. This program should take full advantage of the accumulated knowledge on cultivation of this palm. The Venezuelan Government should organize a research and technical service directed specifically to the development of a large-scale African palm oil industry.

American Oil Palm (Corozo oleifera). This palm, which is indigenous to the Western Hemisphere, should be planted experimentally in various locations, including those where the African oil palm is planted and elsewhere, since it apparently grows and yields well in localities where the African oil palm does not thrive. It also apparently has other advantages over the African palm.

Wild Oil-Bearing Palms. The wild palms of Venezuela, including the genera *Scheelea, Orbignya, Maximiliana, Acrocomia, Manicaria, Astrocaryum,* and *Jessenia,* exist in large numbers and produce large quantities of vegetable oil.

Concentrations of palms south of Lake Maracaibo, the Palma Sola area, and the Upper Orinoco, including Ratón Island and tributaries near-by, are the largest and most productive in areas having transportation and communication with the oil-milling centers of Venezuela. Many problems must be solved before exploitation of these resources is economically feasible. The principal deterrents to exploitation are lack of adequate cracking machinery, inadequate and high-cost labor supply, and extremely high transport and handling charges.

It is possible that limited exploitation of wild palms might be carried on as an adjunct to other enterprises employing the same type of labor on a seasonal basis. Such enterprises might include plantation cultivation of African oil palms or coconut palms, logging operations, etc.

A combination of logging and palm-nut collection might be developed that would provide trails, a system of labor, distribution of equipment and supplies, adequate organization and supervision. This would result in some land-clearing, thereby operating to reduce competition of other growths with the wild palms, and could include some replanting. The result could be the gradual conversion of wild palms to a semiplantation system as was done in the Belgian Congo and elsewhere during the early development of the African oil palm industry. Even this form of gradual development will require a great deal of labor, considerable equipment, capable management, and adequate capital.

In view of these considerations it is recommended that the Venezuelan Government, in a few favorable areas such as Palma Sola and Encontrados, undertake carefully supervised small-scale exploitation to determine the nature and extent of the problems involved, probable costs and returns, and the general feasibility of the operation from a social-economic point of view. Even if not economical under present conditions, such a venture would provide a backlog of information and experience that could be used in case of a future emergency to augment the supply of fats, which are vital to the health and well-being of the nation. The Mission does *not* recommend that the Government attempt or finance large-scale exploitation of wild palms.

It is further recommended that a co-ordinated and continuing program be initiated in Venezuela to extend the survey begun by the Mission to collect, identify, and catalog every type of oil-bearing palm in Venezuela and to make complete and accurate chemical analyses of the fruit of each species. This should be a part of a program to determine the extent of all resources of Venezuela. It is possible that, in the course of a systematic and continuing program of this type, valuable vegetable-oil resources may be found that can be developed in the future.

LITERATURE CITED

[1] D. W. Jenkins. *Palms of Central America and Mexico as a Source of Vegetable Oil.* Washington: Foreign Economic Admin., Tech. Bull., 1944. Pp. 66.

[2] ———"Use of the Airplane in Vegetation Surveys," *Ecology, 26,* 413-414 (1945).

[3] *Revista del Banco Agrícola y Pecuario* (1945).

[4] *El Mes Financiero y Económico* (1945), p. 126.

[5] M. Montaner. *Geografía Económica de Venezuela.* Caracas: Impresores Unidos, 1942. Pp. 26-27.

[6] R. Kifer. *Fats and Oils in Latin America.* Washington: Pan American Union, 1947. Pp. 79.

[7] D. M. Crawford. "Coconuts in Tropical America," *Agriculture in the Americas, 5,* 203-206, 215-216 (1945).

[8] J. R. Skeen. "Outlook for Palm Oil," *Soap and San. Chem., 24,* No. 3, 49 (March 1948).

[9] P. L. Hansen and R. L. Mighell. *Oil Crops in American Farming.* Washington: U. S. Department of Agriculture, Tech. Bull. No. 940, 1947. Pp. 55.

[10] V. Rogers. *Abacá, Cacao, and the African Oil Palm in Costa Rica.* Washington: Inst. of Inter-American Affairs, Special Rept., 1947. Pp. 33.

[11] Dir. Gen. de Agr. de Guatemala. *La Palma de Aceite.* Guatemala, 1940. Pp. 3-8.

[12] *Report of United States Vegetable Oil Mission to Brazil.* Washington, 1942. Pp. 117.

[13] E. A. Curtler. "Experiments on the Germination of African Oil Palm Seeds," *Malayan Agr. Jour., 14,* 84-87 (1926).

[14] B. Bunting, C. D. V. Georgi, and J. N. Milsum. *The Oil Palm in Malaya,* Malayan Planting Manual No. 1. Kuala Lumpur: Department of Agriculture, Straits Settlements and Federated Malay States, 1934. Pp. 18-27.

[15] B. J. Eaton. "Assured Future for the Oil Palm," *Trop. Agr., 64,* 204-210 (1925).

[16] J. M. Dalziel. *Useful Plants of West Tropical Africa.* London, 1937. Pp. 499-507.

[17] American Oil Chemists' Society. *Official and Tentative Methods.* Chicago, 1946.

[18] S. T. Bauer and K. S. Markley. "Hydrogenated Cottonseed Oil as a Substitute for Palm Oil in the Production of Tin Plate and the Cold Reduction of Steel," *Oil & Soap, 20,* 1-11 (1943).

[19] C. F. Poe and H. A. Fehlman. *Food Research, 9,* 500-504 (1944).

[20] G. S. Jamieson. *Vegetable Fats and Oils,* 2nd Ed. New York: Reinhold Publishing Co., 1943.

[21] Anon. *Bull. Imp. Inst., 17,* 186-189 (1919).

[22] C. Pesce. *Oleaginosas da Amazonia.* Belem, 1941. Pp. 128.

[23] W. J. Blackie and G. R. Cowgill. "Occurrence of Carotene in the Oil of *Attalea gomphococca* Mart. and its Relation to Vitamin A Potency," *Food Research, 4,* 129-133 (1939).

[24] H. Pittier. *Manual de las plantas usuales de Venezuela.* Caracas: Litografía de Comercio, 1926. Pp. 458.

[25] O. Grünwald. *Las Palmas* Attalea (Orbignya) *Riqueza Inexplotada de Venezuela.* Caracas: Min. de Agr. y Cría, Bol. *4,* 1-54 (1947).

[26] H. Pittier, T. Lasser, L. Schnee, Zoraida Luces de Febres, y V. Badillo. *Catálogo de la Flora Venezolona,* Vol. *1,* 1945. Pp. 132-145.

[27] G. S. Jamieson and R. S. McKinney. "Patua Palm *(Oenocarpus bataua,* Mart.)," *Oil & Soap, 11,* 207, 217-218 (1934).

[28] C. Grimme. "Some More Recent and Little Investigated Oil Fruits," *Chem. Rev. Fett.-Harz-Ind., 17,* 233-237 (1911).

[29] A. F. Bacharach. "Two Plant Products from Colombia," *Analyst, 43,* 289-291 (1918).

[30] G. Collin. "The Kernel Fats of Some Members of the Palmae," *Biochem. J., 27,* 1366-1372 (1933).

[31] "Kokerite Fruits from British Guiana," *Bull. Imp. Inst., 25,* 1-6 (1927).

[32] L. H. Bailey. "Acrocomia—preliminary paper," *Gentes Herb. 4,* 421-476 (1941).

VI Cultivated Oilseed Crops

This information gathered by observation, from government departments, and from printed sources form the basis of the Mission's recommendations for the production of annual oilseed crops in Venezuela. General recommendations are made on potential regions for oilseed crop production, factors to consider in the choice of oilseed crops, and specific crops for immediate or potential commercial planting.

Potential Regions for Oilseed Crop Production

During the past few years the production of sesame has been centered in the states of Falcón, Aragua, and Carabobo. Until recent years the major area of sesame production has been in the Paraguaná Peninsula, state of Falcón. Reports from this area indicate that the crop is often a complete or nearly complete failure because of drought. Rainfall at Coro, Falcón, during the 20 year period 1921 to 1940 averaged 434 millimeters and ranged from 253 to 773 millimeters.[7] These low rainfall records indicate that frequent crop failures should be expected. Because of the frequency of severe droughts in the Paraguaná Peninsula, this area should not be considered for expanded production of oilseed crops.

Culture of sesame and possibly other oilseed crops could be greatly expanded in many of the fertile valleys of the western and northern highlands, but such expansion is probably not practical because these areas are heavily utilized for food production. In order to increase oilseed production without reducing needed food supplies, it is necessary to consider areas of the country which are not yet fully developed.

A number of potential agricultural areas was suggested in 1942 by the U. S. Soil Conservation Mission to Venezuela.[7] From a study of its report, meteorological data [7], and information obtained at the Soils (*Suelos*), Agronomy (*Agronomía*), and Genetics Branches, Institute of Experimental Agriculture, three regions were considered best adapted to oilseed production. These are the foothill and adjacent *llanos* areas in Portuguesa; the rolling *llanos* in the vicinity of Pascua Valley, Tucupido, Zaraza, and Onoto, state of Guárico; and the foothill regions of Guárico.

Some of the soil types in these areas are not satisfactory for growing oilseed crops. Most of the soils are low in organic matter and natural fertility and would require good soil management to maintain production over a period of years. In these areas crops that can be harvested with combines would have considerable merit from the standpoint of maintaining organic mattter.

A survey was made of the foothills and adjacent *llanos* in Portuguesa (Figures 31 and 32). This region is characterized by nearly level plains normally covered with grass and widely scattered trees (savanna). Streams are commonly bordered by strips of forest varying in width from a hundred meters to more than a kilometer. The savanna areas with better soil types could be used immediately for expanded sesame production (Figure 33) and for the production of other oilseed crops. Some of the forested areas along streams and rivers which are not subject to periodic flooding are also potentially good areas for growing oilseed crops. This region has an average annual rainfall of approximately 1,000 millimeters, most of which occurs during the six months from April to September.[8] The area is well adapted to mechanized farming.

No rainfall data were available for the foothill regions of Guárico, but it appears that they might have ample rainfall to produce oilseed crops unless they are planted too near the end of the rainy season. In 1947, one field of sesame in this area was reported to be a failure because of drought. It would, therefore, seem desirable to expand oilseed crops slowly in this area, until more yield and climatological data are obtained.

The rolling *llanos* in the vicinity of Pascua Valley, Tucupido, Zaraza, and Onoto would require clearing in some areas before they could be used for oilseed crops, and they must be considered less available for immediate expansion of production.

Factors Influencing the Choice of Oilseed Crops

The most important factor affecting the choice of an oilseed crop is its adaptability to climatic and soil conditions. It is apparent from previous experimental tests that some varieties of sesame,

Figure 31. *Llanos* and foothills in the state of Portuguesa.

sunflower, groundnuts, castors, and soybeans are adapted to Venezuelan conditions. Probably the next most important factor is the cost of producing a kilogram of oil per hectare.

The value of any crop is in general determined by the yield and value of the products compared with the cost of production. Tables 39 and 40 show the relative values of various oilseed crops in the United States. Cotton occupies an anomalous position since it is not, strictly speaking, a primary oilseed crop but a fiber crop of which linters, hulls, oil, and meal are by-products.

Generally speaking, data on comparative yields of the various oilseed crops are not available in Venezuela. Comparative tests should be made with one or more of the better varieties of sesame, sunflower, groundnuts, soybeans, and maize at several locations where the cultivation of oilseeds is contemplated. The effect of these crops on the yield of succeeding crops should also be studied.

Caution should be exercised in making broad recommendations on the basis of this comparative crop study, because the results would apply only to the specific area of the test and to areas having similar soil and climatic conditions. For example, some very light soils in the area of Lake Valencia should be well adapted to growing groundnuts unless disease or insects are a

Figure 32. Land preparation in typical foothill and *llanos* country, state of Portuguesa. The plowed area in the foreground was grassland a few years ago. Photograph taken on the Guache hacienda, Acarique District.

limiting factor; other areas with similar climatic conditions may have heavy soils entirely unsuited to this crop.

Although the cost of producing a kilogram of oil per hectare should be one of the most important factors in selecting a given oilseed, other considerations are also important. One of these is ease of producing a crop. Time of planting, cultivation, harvesting, etc., should fit well into other farm operations. Some oilseed crops are more critical regarding the time cycle of these operations and would be less desirable than less critical crops. For example, if present varieties of sesame are not harvested at the proper time there is excessive loss of seed. Harvesting should be done at a time when other crops grown on the same farm do not demand attention. Crops requiring special machinery are less desirable than those that can be produced with machinery already available. Last, but not least, is acceptance of the crop by the producer. Usually it is not difficult to obtain the co-operation of a few

TABLE 39.—COMPARATIVE YIELDS IN KILOGRAMS TO THE HECTARE AND PER MAN-HOUR FOR VARIOUS OILSEED CROPS[1]

Product	Soybeans		Groundnuts		Cottonseed	
	Kg./ha.	*Kg./man-hr.*	*Kg./ha.*	*Kg./man-hr.*	*Kg./ha.*	*Kg./man-hr.*
Oil	191	6.4	241	1.6	78	....
Meal	1,020	34.3	347	2.4	230	....

[1] Five-year average production in the United States.

TABLE 40.—AVERAGE YIELDS OF OIL AND OIL MEAL PER 100 KILOGRAMS OF OIL-BEARING MATERIAL, RATIO OF OIL MEAL TO OIL, AND VALUE OF OIL MEAL PER DOLLAR OF OIL, UNITED STATES[4]

Oil-bearing material	Yield per 100 Kg.		Oil meal per kg. of oil	Value of oil meal per dollar of oil[1]
	Oil	Oil Meal		
	Kilograms			
Cottonseed	15.5	45.0	2.90	$0.58
Flaxseed	34.0	64.0	1.88	.38
Groundnuts	29.0	43.6	1.50	.30
Soybeans	15.0	80.0	5.33	1.07
Sesame seed	47.0	48.0	1.02	.20
Copra	63.0	35.0	.56	.11
Palm kernels	45.0	53.0	1.18	.24
Babassu kernels	63.0	35.0	.56	.11
Sunflowerseed	25.0	73.0	2.92	.58

[1] Based on an assumed value of oil per kilogram five times that of oil meal.
[4] Refers to literature cited at end of chapter.

farmers to produce a new crop. The relative degree of success obtained by the few producers who first grow a new crop will determine to a marked extent the acceptance of the crop in a new area. Therefore, it is important that promotion of a new oilseed crop be based on sound experimentation and that the producer be given sufficient information on cultural practices to make his production successful.

Specific Oilseed Crops

Sesame (*Sesamum indicum*)

Sesame has been an oilseed crop of some commercial importance in Venezuela since 1912.[5] Annual yields during the period 1936-46 are given in Table 41. It is obvious from this table, and from data on experimental production at the Institute of Experimental Agriculture, that sesame is adapted to the climatic conditions in Venezuela. This crop has generally been grown in countries where hand labor is cheap and plentiful. In areas where crops are produced by hand labor, sesame is an exceptionally good oilseed crop. In regions where all crops are produced by mechanical means, the comparative cost of producing sesame with dehiscent capsules is high in comparison with that of many other oilseed crops. The main objection to the best sesame varieties now available for commercial planting is the dehiscent nature of the mature capsules. Other objectionable features of this plant are the difficulty of obtaining stands and poor competition with weeds immediately after emergence. Good features are drought resistance and high yield of oil per hectare.

In 1940, an intensified sesame-breeding program was begun in Venezuela by Dr. D. G. Langham (Figure 34). One of the outstanding accomplishments of this research was the discovery of an indehiscent type of sesame.[6] The development of adapted varieties possessing this character will have a marked influence on the production of sesame in Venezuela and other countries. Several indehiscent Venezuelan lines are being increased, and it appears that an adapted variety having this character may be available for extensive commercial planting within a few years. In the meantime, varieties having dehiscent capsules, such as Venezuela 51 and 52, must be used.

Because of the limited data available on other annual oilseed crops, sesame must be considered the best oilseed crop now available for immediate large-scale expansion. After a few years of research and increased seed production, others may become of considerable importance. Recommended practices for the production of sesame in Venezuela have been published. For this reason, only improved practices are discussed here. These suggestions are based on experience with the production of sesame on a semicommercial scale in the state of Nebraska, U. S. A.

Figure 33. Sesame in shocks on El Camercito hacienda, Portuguesa. Two-year average yields of sesame on this hacienda were approximately 1,000 kilograms per hectare.

TABLE 41.—ANNUAL PRODUCTION OF SESAME, 1936-46[1]

Period	Area planted	Yield
	(*Hectares*)	(*Kg./ha.*)
1936-40 av.	1,500	600
1941	1,400	700
1942	3,650	800
1943	4,514	800
1944	938	600
1945	3,569	800
1946	3,125	800
1941-46 av.	2,245	682

[1] Data from Division of Agricultural Economics, Ministry of Agriculture and Livestock.

The Agronomy Branch, Institute of Experimental Agriculture, Maracay, has developed a three-row sesame planter by modifying three Planet Junior hand planters. Although a very light machine, it is reported to be satisfactory for commercial planting. But, in order to use this planter, it is necessary for each producer to have a specially built machine. On farms where corn planters are available, it would be preferable to use them for sesame. It may be necessary in some cases to have special plates made for the planters in order to handle sesame seed. However, the John Deere planter has been used in Nebraska to plant sesame with very good results. Edge-drop plate No. Y-5364-B with false ring No. Y-5055-B was used. This plate has 16 openings, 6 millimeters in length by 3 millimeters in width (upper surface). This combination of plates and false ring plants at the rate of one-half to several kilograms of sesame seed a hectare, depending upon the setting of the variable drop lever.

Figure 34. Dr. D. G. Langham, pioneer sesame breeder in Venezuela, holding a bundle of sesame on El Camercito hacienda.

Calibrations have not been made for planting sesame in all planters, but all those equipped with edge-drop plates can be adapted to this use. Sesame plates should be of the edge-drop type unless planting rates are two kilograms or more per hectare. When using planting rates of less than two kilograms, plates of center-hole type are apt to become clogged by seed lodging endwise.

In some planters, sesame seed is lost around the edges of the seed box. This loss can be eliminated by puttying the edges of the box. Occasionally seed is crushed between the plate and false ring. This difficulty can be eliminated by widening the lower width of the holes so that any seed held in the upper part of the hole will easily drop through.

In Nebraska, an ordinary grain drill has been tried with varying degrees of success for planting sesame. For planting rates of 3 or more kilograms per hectare this machine can be adjusted to operate satisfactorily. It is necessary to close a number of feeds, depending upon the desired width of row. By using existing equipment to plant sesame, it may not be necessary for farmers to buy special planting machinery.

Mechanical harvesting has been done in Venezuela with ordinary grain binders. They have also been used in the United States and are satisfactory if the sesame is not taller than 1.2 meters and if it is not heavily branched. Plants more than 1.2 meters high can be more conveniently harvested with a maize binder.

Standard maize binders can be adjusted to tie strings from 52 to 75 centimeters from the base of the butts. They should be used on sesame 1.5 meters or more in height. Short maize binders can be adjusted to tie strings 30 to 55 centimeters from the butts. They could be used to harvest sesame 1 to 2 meters high. Maize binders are made to harvest either one or two rows.

Two common methods are used to thresh sesame in Venezuela. One is to place bundles upside down over a canvas or tarpaulin and beat out the seed. The other employs a stationary thresher. It is difficult to transport bundles of sesame from shocks to a stationary thresher without losing considerable seed and the operation requires a great deal of labor.

A more satisfactory method is to thresh the seed from the shock with a small combine, as shown in Figure 35. The cycle-bar, reel, and concaves are removed from the combine, the cylinder is raised as far as possible, and the

machine is run at a low speed, 250 to 500 r.p.m. A flax sieve is used in the cleaning mechanism.

In threshing from the shock, a tarpaulin is laid down by the shock, which is dumped onto it. The combine is driven up to the edge of the tarpaulin, facing the tips of the bundles. The bundles are thrown, tip forward, on the canvas of the combine. If the bundles are small and are not tied too tightly, it is not necessary to cut them; if they are large it is necessary to cut strings as they are fed into the combine. After the bundles have been fed through the machine, about half of the seed remains on the tarpaulin. It is then lifted by the corners (two men, one on each side) and the seed and leaves poured on the canvas of the combine. A crew of three men, one on the tractor and two handling the canvas and feeding bundles into the combine, works very satisfactorily. By this method of threshing two to four hours are required to thresh one hectare of sesame. By proper adjustment of air and sieves, the seed is cleaned adequately for sale to the oilmill.

Since sesame is somewhat difficult to grow, experienced agriculturists who are familiar with the problems would assist materially in expanding its production.

Figure 35. Threshing sesame from the shock with small combine in Nebraska, U. S. A.

Sunflower (*Helianthus annuus*)

Production tests with sunflowers were conducted at El Valle, Federal District, in 1938 and 1939. Yields of the Giant Russian variety averaged approximately 1,200 kilograms of seed per hectare.[7] Small commercial plantings in Aragua indicated that yields of 1,200 to 2,000 kilograms per hectare could be obtained with this variety.[8] At that time, sunflowers were considered a promising crop for Venezuela. Experimental work was discontinued during World War II.

Plantings of sunflowers for observation were made in 1947 by the Agronomy and Genetics Branches, Institute of Experimental Agriculture. Although no yield tests were made, several varieties, Klein, Skorospelki, and Advance Hybrid, which are adapted to harvesting by combine, were considered as having done very well. Observations were made of several varieties growing under irrigation in increase plots on the experimental farm of the Genetics Branch. These varieties were planted in early January 1948 and began to flower on 20 February. Prospects at that time were for an excellent increase of seed.

Although experimental data on sunflowers in Venezuela are not extensive, those available indicate that at least some varieties are adapted to the soil and climatic conditions. Sufficient tests are lacking to show which is the best-adapted variety. The Giant Russian, which was used in early tests, is too tall to harvest by combine, so it would not be suitable for large-scale production. Varieties that do not grow taller than 1.5 meters can be combine-harvested; such varieties have been developed in Canada and in some South American countries.

No information is available on comparative tests of sunflowers with sesame. Sunflowers would probably produce a considerably greater weight of seed per hectare than sesame, but because of their lower oil content they probably would not produce more oil per hectare. However, sunflowers have some advantages over the present varieties of sesame: (1) it is much easier to establish sunflower stands, planting can be made at depths of 2 to 5 centimeters and under rather adverse conditions; (2) sunflower growth is more rapid immediately after emergence, which is important from the standpoint of weed control; and (3) harvesting is much less costly, since sunflowers can be combine-harvested in the field.

A disadvantage of sunflowers in comparison with sesame is the possibility of bird damage before harvest. Since sunflowers have not been produced commercially in Venezuela, there is also the possibility that some serious disease may develop under conditions of large-scale cultivation. However, limited tests made to date indicate that the crop is relatively free of insect pests and diseases.

Figure 36. Sunflowers planted at the rate of approximately 5 kilograms to the hectare. Such stands give good yields and, because of fine stems and small heads, are easily harvested with a combine.
(Photo by courtesy of E. D. Putt, Co-op Vegetable Oils Ltd., Altona, Manitoba, Canada)

Figure 37. Sunflowers planted at the rate of approximately 2 kilograms to the hectare. Coarse stems and large heads are hard to handle with a combine.
(Photo by courtesy of E. D. Putt, Co-op Vegetable Oils, Ltd., Altona, Manitoba, Canada)

It is suggested that a portion of the sunflowerseed from the three varieties increased by the Genetics Branch be used for further increase of seed during the next several years. Production tests by the Institute of Experimental Agriculture should show within several years which variety, if any, should be produced on a large scale. If experimental tests during the next two or three years show that one or more of these varieties is adapted to commercial production, seed would then be available for large-scale planting. Seed from varieties increased but not found adaptable for commercial planting can be sold to oilmills. If production tests show that none of the varieties of sunflowers is sufficiently promising all available seed can be sold for oil-milling. At the same time, considerable experience can be obtained in crop-production methods and in methods of harvesting with combines.

To prevent loss of sunflowerseed by shattering during harvest it is necessary to make a number of modifications on the combine. The quantity of seed lost during harvest depends on spacing of the plants in the field and adjustments made on the combine. A low rate of planting, 2 or 3 kilograms to the hectare, may result in the same yield as a planting rate of 5 to 7 kilograms to the hectare. The large heads of seeds produced in fields planted at low rates are difficult to handle with a combine (Figures 36 and 37) and it is preferable to plant enough seed so that only small heads are formed.

All modifications of the combine required for harvesting must be made by the farmer. To prevent sunflower heads from hooking over the reel slats, the area between the reel arms should be filled in with thin boards or with fine-mesh heavy-gauge wire. An extension 20 to 30 centimeters long is commonly added to the reel, usually at an angle of about 30° with the reel arm in the direction of rotation (Figure 38). To catch seed shattered by the reel and to raise low-hanging heads, wide guards are generally installed on the cutter bar. These guards should be about 10 centimeters narrower than the row width and about 1 meter long.

The engine speed should be reduced to about 500 r.p.m., but it is important to keep the remainder of the machine running at normal speed. The cylinder should be raised to give considerable clearance between concaves and cylinder bars. Combines with bar-type cylinders are more satisfactory for harvesting sunflowers than the spike-tooth types. The exact amount of clearance between concaves and cylinder bars depends on the variety of sunflowers grown and conditions

at the time of harvest. For more details on the adjustments required, the article by Putt [9] should be consulted. At present no factory makes attachments that can be used for harvesting sunflowers. The attachments or modifications made by farmers in Canada and the United States are quite variable. Those described above are considered the best now available.

Soybeans (*Glycine max*)

Production tests with several soybean varieties were conducted at El Valle, Federal District, during the period 1939-42 by Alexandre Alexandrow. Data from the 1939 test are given in Table 42. Yields, in kilograms per hectare, for varieties tested in 1941 are as follows: Mammoth Yellow, 2,571; Oto-o-tan, 2,555; White Biloxi, 1,600; Harbinsoy, 1,500; Hollybrook, 1,500; Biloxi, 1,400.

The 1939 yields are exceptionally low compared to the over-all average production in the United States that year—approximately 1,400 kg./ha. (20.7 bushels per acre). However, all yields reported for the 1941 experiments were higher than the over-all average in the United States (18.0 bushels per acre) for that year and in the case of some varieties were approximately twice as great.

The low yields of 1939 may have resulted from late planting. The Biloxi variety, which was planted in September, produced a very low yield of seed. Planting dates of the 1941 test were not available to the Mission. Although the effect of the date of planting on the yield of soybeans has not been determined in Venezuela, it is probable that plantings made in early June will produce higher yields than plantings made in July or later.

No yield data for soybeans were found in *Memoria y Cuenta* (Annual Report), Ministry of Agriculture and Animal Husbandry for 1942, but it was stated that Mammoth Yellow, Oto-o-tan, and Biloxi were the best varieties. Dr. A. Bonazzi, who was employed at the El Valle Experiment Station at the time the soybean experiments were in progress, said in a personal interview that soybeans were also tried on a semicommercial scale in the area of Lake Valencia with good results and he believes this crop has possibilities for large-scale production in Venezuela. In the annual reports of the Ministry of Agriculture and Livestock [7] mention is made of the promising commercial possibilities of soybeans as an oilseed crop and as a source of human food.

TABLE 42.—YIELD DATA FOR SOYBEANS GROWN AT EL VALLE, FEDERAL DISTRICT, 1939

Variety	Date		Yield
	Planted	Harvested	*Kg./ha.*
Oto-o-tan	7 July	18 Oct.	700
Mammoth Yellow	22 July	1 Nov.	250
Mammoth Yellow	10 July	25 Oct.	250
Biloxi	9 Sept.	21 Dec.	30

Figure 38. Self-propelled augur-type combine showing reel and guard modifications commonly used in harvesting sunflowers.
(Photo by courtesy of E. D. Putt, Co-op Vegetable Oils, Ltd., Altona, Manitoba, Canada)

Experimental work and demonstration plantings during the period 1943-46 were apparently discontinued. During early June 1947 the Agronomy Branch planted observation plots of approximately 100 varieties. Many varieties, such as Lincoln, which is one of the better varieties in the Corn Belt of the United States, flowered approximately 20 days after emergence and matured within 45 to 60 days after planting. Most of these varieties attained heights of only 8 to 20 centimeters. Their response to the short length of day in the tropics apparently resulted in very early flowering. However, some varieties, such as Biloxi and Seminole, were apparently quite normal in behavior, flowering about 45 days after emergence and maturing in 100 to 120 days after planting. They attained heights of 60 to 80 centimeters and produced heavily. Although

no yield data were taken on these plots, the Agronomy Branch considered the results encouraging, and more extensive trials are planned during the next few years.

Dr. Steinmetz, a soybean enthusiast who is farming near Maracay, reported unusually good yields. The unidentified black-colored variety he exhibited is of unknown value to any member of the Mission. Superficially, it resembles the black forage-type soybean grown in many sections of the United States and particularly in the southern states. These soybeans are generally low in oil content. Because of that fact and the necessity of hulling before processing for oil, they are generally not acceptable to oil millers. Dr. Steinmetz was reluctant to furnish a sample of his soybean, which he has named the Santa María, either to the Institute of Experimental Agriculture or to the Mission for analysis and agronomic testing.

Although the information that could be obtained on the cultivation of soybeans in Venezuela was very meager, there are indications that some varieties may offer possibilities of becoming an oilseed crop. Soybeans appear to be of special interest to Venezuela for several reasons: (1) field beans are a common field crop and it would not be difficult to educate farmers to grow soybeans; (2) although not a good soil-building crop, the soybean is nevertheless a legume and may be of some value to soils known to be low in nitrogen; and (3) production can be entirely mechanized with equipment already existing in Venezuela.

Efforts should be made to obtain the best variety adapted to Venezuelan conditions and considerable care should be taken to avoid releasing any variety which has not been proved worthy of commercial production. Research should be directed especially to cultural practices, including the most advantageous dates, rates, and methods of planting. Such a research program could be started immediately with the Biloxi or Seminole varieties.

Groundnuts (*Arachis hypogaea*)

Groundnuts (peanuts) are grown on a limited scale in Falcón, Aragua, Carabobo, and Yaracuy. Venezuelan statistical reports indicate that the average yield of groundnuts in the shell from 1941 to 1946 is 880 kilograms per hectare. Three varieties are grown—Valencia, Tennessee Red, and Improved Spanish.

Venezuelan farmers seem to prefer the Tennessee Red variety, which has been imported in appreciable quantities, especially for planting. This variety is little grown in the United States and is a poor groundnut for oil production. It produces three or four seeded pods, is low in oil content, and has a tendency to sprout in the ground before it can be harvested, a tendency which is greatly accentuated in the tropics. The only field of unharvested groundnuts seen by members of the Mission was of this variety. They were still immature but harvesting in the next day or two was considered necessary to avoid loss of the crop by sprouting. The field was spotty as a result of plants having died or because some seed failed to germinate, and the surviving plants were suffering from insect, bird, and leaf-spot damage.

The preference for this variety is difficult to understand, especially from the point of view of oil production. A possible explanation is offered by Dr. B. B. Higgins, Georgia Experiment Station (U. S. A.), who informed the Mission that this type of groundnut was grown by the early Spanish settlers in the southwestern United States and that they apparently got the seed from the Indians. Dr. Higgins believes this variety was grown by Indians throughout the Caribbean and Central America in pre-Columbian times and acquired the various Indian names by which the groundnut is known in these areas. He believes the word *maní* is of Carib origin and was in common use before the discovery of America. If these conjectures are correct they may account for the long-established preference of Venezuelan farmers and consumers of edible groundnuts for the Tennessee Red variety rather than for the so-called Spanish type, which is superior for oil-milling.

Harvested and partially cured groundnuts were observed in a large pile on an *hacienda* in Portuguesa. These were of a Spanish variety and were in very poor condition, many nuts being moldy and rotten, either as a result of improper and inadequate curing or because of damage while still in the ground.

The Genetics Branch grew 186 varieties of groundnuts in an observation nursery in 1947 but no yield data were taken. Three varieties, Cuba 47-98, Tennessee Red, and a Hawaiian strain, which appeared especially promising, were placed in increase plots under irrigation during the summer. Plans at the time of the Mission's visit were to put these three varieties through

replicated yield tests in 1948. The increase plots of groundnuts appeared to be in excellent condition. Some plants were damaged by termites, but such damage is probably never very great, except in fields having considerable woody residue.

Fungus attack upon groundnuts before germination is a serious problem in the United States and it would be expected to be worse in tropical countries. Pretreatment of seed with fungicides is especially important in Venezuela, as the Agronomy Branch has found. Groundnuts treated with Uspulum gave better stands than untreated seed. A number of other fungicides, found effective in promoting increased germination in the United States, should be tried in Venezuela. Two-percent Ceresan, Arasan, and Spergon have all proved effective at the Georgia Experiment Station, but Ceresan is significantly better than any other product tested.

Groundnuts appear to have considerable possibilities in some of the valleys with light sandy soils such as are found in some areas around Lake Valencia. Many of the soils in the *llanos* and foothills are too heavy. Production of this crop requires considerable labor and some special machinery. More research is needed to establish its value in relation to other oilseed crops.

If large-scale production of groundnuts is contemplated in Venezuela, consideration should be given to the Unilever Ltd. and British Government [10] development in East and Central Africa, which contemplates planting 1,300,000 hectares to this oilseed crop.

Castors (*Ricinus communis*)

Some castors were grown commercially in Venezuela during World War II, but since then all commercial production has been discontinued. There are two reasons for this change: the difficulty of harvesting with hand labor and the prevalence of the disease, *Sclerotinia ricini*, which apparently damages capsules of spiny varieties.

The Genetics Branch has done some breeding work on improved varieties of castors. It finds that spineless varieties are resistant to or escape *Sclerotinia ricini*. It has also developed spineless dwarf varieties which grow to heights of approximately 1.5 to 2 meters and yield approximately 2,000 kilograms of seed per hectare. Such high-yielding varieties of castors should have considerable promise, especially if harvesting can be mechanized.

Figure 39. Experimental castor harvester developed by the University of Nebraska, U. S. A.

Work on the development of a castor harvester has been in progress at the University of Nebraska (U. S. A.) for several years, one result of which is the experimental harvester shown in Figure 39. Commercial production of an improved form of this machine is now in progress by the Belle City Manufacturing Company, Racine, Wisconsin, U. S. A. The harvester operates on the stripper principle and cannot be used until the plants are defoliated by frost or other means. It handles varieties up to 3 meters in height, collecting seed in the hull. Commercial hullers are also available.

Dr. Wayne Domingo, agronomist for the Baker Castor Oil Company, found during his work in southern California, U. S. A., that chemical defoliants have possibilities in preparing castor plants for mechanical harvesting in regions where there are no frosts. He applied "X5" dust manufactured by the American Cyanamid Company at the rate of 11 and 22 kilograms per hectare and in both cases the plants dropped all except the youngest leaves within seven to ten days after dusting without injury to the plants. New growth starts shortly after chemical defoliation and racemes not fully ripe at the time of treatment are reported to ripen shortly thereafter.

The castor harvester developed by the University of Nebraska, or some modification of it, should be tried experimentally after chemical defoliation, especially with dwarf varieties. It is suggested that castors be planted in June or July and that chemical defoliation be tried during the latter part of the dry season. By February

Figure. 40. Transportation in Maracaibo.

or March racemes that flowered as late as early December should be mature. Racemes flowering in January and February would probably not fill out with good seed because of drought and no great loss would result from chemical defoliation. Research on chemical defoliants under Venezuelan conditions should be done before any work on a mechanical harvester is attempted.

Production of castors in Venezuela will require considerable research before they can be considered for large-scale planting unless hand labor is used for harvesting, but even in this case chemical defoliation would still be advantageous.

Flax (*Linum usitatissimum*)

In 1941, Riga No. 2 variety, a fiber type of flax, yielded 900 kilograms of seed per hectare.[7] This variety produced the highest seed yield of those tested.

Flax does best in regions having relatively low temperatures during the early part of its vegetative growth. It is doubtful that flax would yield as well in the Lake Valencia region or in the states of Portuguesa and Guárico as at El Valle. However, it is suggested that observation plantings be made in the vicinity of Maracay to determine the feasibility of growing the crop in the high temperatures of this area.

TABLE 43.—ANALYSIS OF VENEZUELAN SAFFLOWER[1]

Sample No.	C–11–12 Nebr. 804	C–11–12 Nebr. 79	C–8–12 Indian	C–8–12 Nebr. 55	C–8–12 Nebr. 852	Nebr. 805
			Percent			
As-received basis						
Moisture	6.67	6.34	6.25	6.24	5.85	5.80
Nitrogen	2.95	2.92	2.87	2.87	3.07	3.20
Protein (N x 6.25)	18.44	18.25	17.94	17.94	19.19	20.00
Total lipids	21.82	23.12	26.19	27.19	29.48	31.10
Moisture-free basis						
Nitrogen	3.14	3.12	3.06	3.06	3.26	3.40
Protein (N x 6.25)	19.76	19.49	19.14	19.13	20.38	21.23
Total lipids	23.38	24.69	27.94	29.00	31.31	33.01

[1] All analyses are the averages of two or more closely agreeing determinations and were supplied by the courtesy of T. H. Hopper, Head of the Analytical, Physical Chemical and Physics Division, Southern Regional Research Laboratory, New Orleans, Louisiana, U. S. A..

Safflower (*Carthamus tinctorius*)

In 1947, a number of samples of safflower seeds were sent by the University of Nebraska to Dr. Langham of the Genetics Branch. These seeds were planted at Maracay on September 6 of that year. They flowered early in November and the seed was harvested after maturity, approximately four weeks later. To produce a good set of seed and high oil content, safflower requires low relative humidity from the time flower budding begins until after maturity. The oil content of this seed is highly variable, depending also upon variety and region of cultivation.[11]

Samples of safflower seed collected at the Institute of Experimental Agriculture were sent to the Southern Regional Research Laboratory, New Orleans, where analysis revealed the results shown in Table 43. There was a difference of 50 percent between the oil content of the highest and lowest samples. This high variability is typical of safflower varieties.

Comparative oil content of the same three varieties grown at Maracay, Venezuela, and in the western United States are given in Table 44. The oil content is somewhat higher for seed produced in the United States, but that of the seed grown at Maracay is sufficiently high to warrant additional tests, especially to obtain data on yields that may be expected under Venezuelan conditions.

Safflower should do well in Venezuela at altitudes above 1,000 meters. It may be possible to grow this crop under irrigation if planted during the dry season, or even without irrigation if planted toward the end of the rainy season.

TABLE 44.—COMPARATIVE OIL CONTENT OF SAFFLOWER VARIETIES GROWN AT MARACAY, VENEZUELA, AND IN THE UNITED STATES

Variety	Oil content[1]	
	Maracay	United States[2]
Indian	26.2	29.9
N-805	31.1	33.9
N-852	29.5	34.1
Average	28.9	32.6

[1] Oil analyses reported on as-received basis. Seed contained from 5 to 7 percent moisture.

[2] Average of seed from plantings made at nine locations in the western United States where safflower grows well. Analysis made at the University of Nebraska.

Other Oilseed Crops

Perilla (Perilla frutescens) and *chia (Salvia hispanica)* apparently have not been tried in Venezuela. Both of these plants require short days for flowering. They should be tried experimentally because they are excellent substitutes for linseed oil.

Size of Farm Units

The magnitude of the fat deficit in Venezuela is so great that it is not likely to be overcome by increased production from small-farm operation, primarily because sufficient farm labor is not available and the cost of production is necessarily high. Only large-scale mechanized

farming can relieve the shortage. This and large-scale modernized milling can provide an adequate supply of fats and oils at a cost of finished product more nearly in balance with the purchasing power of the consumer.

Conclusions

Considering the limited agronomic data available on annual oilseed crops other than sesame, and the inability of the members of the Mission to observe such crops in the field at the time of the survey, it is impossible to determine what oilseeds are best adapted to Venezuela. Based on such observations as could be made and such information as was available, it can only be said that three to five years of intensive research will be needed to determine what oilseeds are best, in what areas, and under what conditions they should be grown.

It is possible that sufficient annual oilseed crops could be produced in Portuguesa and Guárico to satisfy all of Venezuela's needs for edible oils without producing an unbalanced agriculture. However, care must be exercised in selecting the better soils for cultivation in these regions and in the maintenance of their organic matter and fertility.

The only possibility of an immediate increase in edible-oil production from an annual oilseed crop is to increase sesame production. Such increased production must be coupled with a good extension program to promote adequate production practices.

Seed stocks of the better-adapted varieties of groundnuts, sunflowers, and possibly soybeans should be built up during the next few years. This program should be carried out in co-operation with research organizations and should be based on reliable data obtained from sound test-plot and field plantings. The commercial production of foreign varieties of seed of unknown adaptability should be discouraged except for experimental purposes. In general, planting unadapted varieties ends in disappointment.

Data on drying oil crops are practically nonexistent in Venezuela. Several years of intensified research are needed before sufficient information can be obtained to decide which crop offers sufficient possibilities to warrant large-scale planting.

In order to become self-sufficient in the production of annual oilseed crops in the shortest possible time, every available agency, such as the Institute of Experimental Agriculture, Agriculture and Animal Husbandry Branch; Oilseed Branch, Venezuelan Development Corporation; Venezuelan Corporation of Basic Economy *(Corporación Venezolana de Economía Básica)*, and others should co-operate in an intensive research, development, and agricultural extension program. Venezuela is in critical need of additional supplies of edible fats and no effort should be spared to attain a more self-sufficient status in this vital dietary factor.

Successful production of oilseed crops cannot be expected to follow indiscriminate planting of unadapted varieties in areas having a soil and climatic environment unfavorable to them, or without adequate knowledge of cultural practices on the part of the grower. Any attempt to expand the production of oilseed crops which is not based on the availability of adapted varieties of planting stocks, or is made on poor soil, or under unfavorable climatic conditions, or with poor farm management, or without adequate machinery for the crop, or combinations of these factors, is bound to be wasteful of time, effort, and money, and to fail in its purpose.

LITERATURE CITED

[1] Epifanio González P. *Climatología de Venezuela.* Caracas: Ministerio de Agricultura y Cría, Dirección de Agricultura, Servicio de Meteorología Agrícola, 1941.

[2] H. H. Bennett, D. S. Hubbell, W. X. Hull, and J. E. Caudle. *Land Conditions in Venezuela and Their Relations to Agriculture and Human Welfare.* Soil Conservation Mission to Venezuela from the United States Department of Agriculture. Washington: Soil Conservation Service, 1942.

[3] Jesús M. Sánchez Carrillo. *Resumen Meteorológico 1940-1945.* Caracas: Ministerio de Agricultura y

Cría, Dirección de Agricultura, Sección de Meteorología Agrícola, Publicación No. 3, agosto, 1946.

[4] P. L. Hansen and R. L. Mighell. *Oil Crops in American Farming.* Washington: U. S. Department of Agriculture, Tech. Bull. No. 940, 1947.

[5] D. G. Langham and M. Rodríguez. *El Ajonjolí* (Sesamum indicum L.), *su cultivo, explotación y mejoramiento.* Caracas: Ministerio de Agricultura y Cría, Boletín No. 2, 1945.

[6] D. G. Langham. "Genetics of Sesame III, 'Open Sesame' and Mottled Leaf," *Journal of Heredity 37,* 149-152 (1946).

[7] *Memoria y Cuenta.* Caracas: Ministerio de Agricultura y Cría, Volúmenes 1939-1942.

[8] Alexandre Alexandrow. "Informe preliminar sobre el cultivo del 'Girasol' en Venezuela." *El Agricultor Venezolano,* No. 49, mayo, 1940. Pp. 18-22.

[9] Eric D. Putt. *Sunflower-Seed Production.* Altona, Manitoba, Canada: Co-op Vegetable Oils Limited, 1948.

[10] Minister of Food. *A Plan for the Mechanized Production of Groundnuts in East and Central Africa.* London: His Majesty's Stationery Office, 1947.

[11] C. E. Claassen. "Safflower, a Potential Oilseed Crop in the Western States." *Chemurgic Digest 7,* 11-17 (March 1948).

VII Processing Facilities

THE EXACT NUMBER of manufacturing plants in Venezuela engaged in processing fats, oils, and oilseeds, and the production of finished products is not accurately known; or at least an accurate list of such plants could not be obtained. The list of plants furnished the Mission contained the names of 26 concerns engaged in the production of crude vegetable oils or finished products such as refined cooking and salad oils and vegetable shortening; two fish-oil plants; one tallow plant; and six creameries. Another list contained the names of 41 firms engaged in the manufacture of soap. It was not possible or even desirable to visit all of these 76 plants, and several of them were found to be nonexistent. However, 11 more or less representative plants were visited by two or more members of the Mission:

Compañía Anónima Industrial Productora de Grasas, Caracas, D. F. Crude and refined oils, shortening, boiled-down soap.

C. A. Fábrica de Aceites de Maracay, Maracay, Aragua. Crude and refined oils.

Casanova y Cía., Maracay, Aragua. Crude oil.

Compañía Anónima FACEGRA, Valencia, Carabobo. Crude and refined oils, shortening.

Pérez Aikman y Cía., Valencia, Carabobo. Crude and refined oils.

Compañía Anónima Las Llaves, Valencia, Carabobo. Soap and candles.

Compañía Anónima Las Llaves, Puerto Cabello, Carabobo. Crude and refined oils, shortening, soap, and candles.

Sociedad Pérez Mena, Puerto Cabello, Carabobo. Crude and refined oils, shortening, boiled-down soap stock.

Factoría de Aceite "Santa Ana," Morón, Carabobo. Crude coconut oil.

Compañía Industrial "La Florida," S. A., Maracaibo, Zulia. Crude and refined oils.

Lactuario "Alfa," Maracaibo, Zulia. Butter and ice-cream.

At all of these establishments members of the Mission were received with courtesy and consideration. In general, frank replies were made to all queries. Both administrative and technical personnel displayed a keen interest in and knowledge of the fat-and-oil problems confronting Venezuela and of their own economic position relative to these problems. Information obtained in the course of these interviews has received careful consideration by the Mission.

Crude-Oil Mills

At the time the crude-oil mills were visited a number of them were not operating because of lack of raw material, or were shut down for repairs, or both. Mills in operation were processing copra, sesame, or cottonseed and several mills were processing more than one type of seed.

These mills varied widely in capacity and type of equipment. The smallest plant (Figure 41) contained a single-cage press capable of handling only one ton of copra per eight-hour day. The largest contained three expellers (Figure 42) and eight hydraulic cage presses (Figure 43).

Figure 41. One-ton-a-day copra mill.

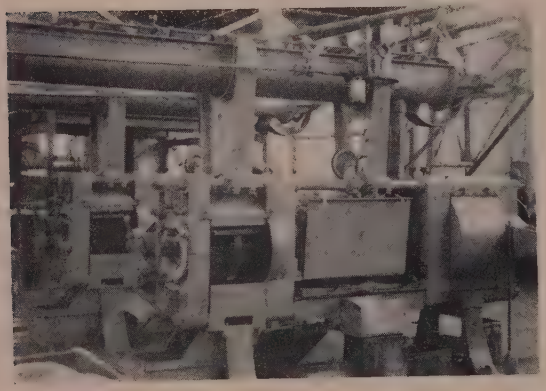


Figure 42. Krupp forepressing expellers.

Equipment of most of the well-known American, British, and German oil-processing machinery firms was observed, often in the same plant (Figures 44 and 45). Much of this equipment is of the smallest possible size, often obsolete or very much in need of repair. In some cases these conditions were not the fault of the management but reflect the difficulties existing since the beginning of World War II in obtaining replacement parts and new equipment.

Almost all of the companies visited have purchased new equipment, in several cases entire

Figure 43. Cage presses for repressing expeller cake.

new plants, or have plans for modernizing their plants. Several of these companies will double or triple their capacities with the installation of new equipment scheduled for delivery during 1948. The low efficiency of some of these plants is, however, not entirely due to poor or inadequate equipment but rather reflects the lack of qualified personnel or inefficient plant management. For example, it is the rule rather than the exception to produce hydraulic press cake or meal containing as high as 7 to 10 percent residual oil. On the other hand, at least one mill processes copra, babassu, and tucum in modern expellers with a residual oil content in the meal of 4 to 4.5 percent.

Still another plant, which processes copra by expeller forepressing and counter-current batch extraction, produces meal containing less than 1 percent of residual oil. This plant operates a four-cell counter-current solvent extraction system (Figure 46) of German manufacture on a 24-hour, two-shift basis. Only four men are employed per shift and none is technically trained. This plant has been in operation for ten years or more without accident arising from the use of hydrocarbon solvents. Despite this record a near-by factory is installing a continuous extraction plant employing a chlorinated hydrocarbon because of the fear of fire or explosion. Although the use of chlorinated solvents reduces the hazard of explosion these solvents have other disadvantages, not the least of which are high cost and toxicity. Unless all traces of such solvents are removed from the meal there is imminent danger of poisoning dairy and beef cattle.

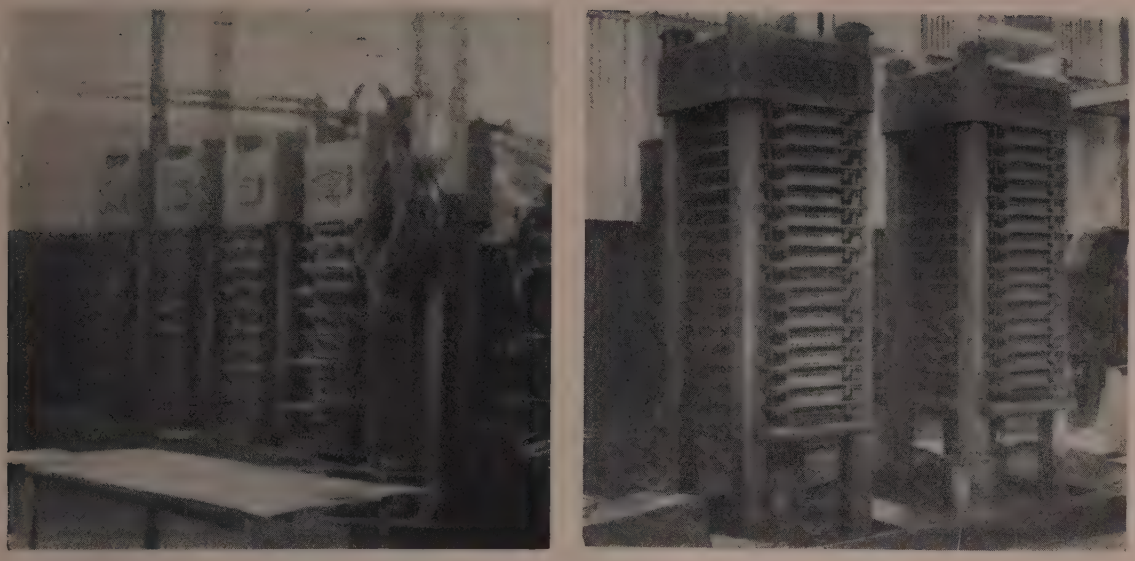


Figure 44. Old (left) and new hydraulic presses in the same mill.

Figure 45. Expellers in the same plant as Figure 44.

In general, the poorest oilmill operation was observed in the processing of cottonseed. Practically all operations, from delinting to pressing, were conducted with relatively poor efficiency. Part of this inefficiency results from the use of obsolete, inadequate, or badly cared-for equipment. In several plants the delintered seed carried excessive amounts of linters and appeared more like undelintered seeds in the United States. Two of these mills had delintering machines of good manufacture, but they showed signs of abuse

Figure 46. Four-cell counter-current batch extraction system used for extracting copra expeller cake.

and misuse. Another mill, with much less experience but with newer equipment, was doing good work and producing almost bald seed.

The most vital operation in delintering cottonseed is the maintenance of sharp teeth of the proper shape on the saws. This requires constant care and frequent sharpening of the saws. To accomplish this operation requires filing and "gumming" or milling machines. Not only must the gin saws be kept sharp but the delintering machine must be kept adjusted to compensate for the wear of the saws resulting from frequent sharpening. One mill the Mission visited was operating delintering machines with hundreds of broken teeth; the saws had not been sharpened for a long time and delintering efficiency was low.

The separation of kernels and hulls was also carried out inefficiently in several mills. This poor separation was probably caused more by poor equipment than by poor operation.

Practically all of these mills were producing press cake containing 7 to 10 percent of residual oil. Any cottonseed-oil mill in the United States leaving such an amount of oil in the press cake would be forced into bankruptcy by competition with more efficient mills. This high residual oil content can be traced to several causes: poor delintering and separation of hulls and kernels, poor rolling or flaking of the meats, inadequate cooking, and inefficient pressing. Not all of these conditions prevailed in any one mill but one or more of them was observed in each of several mills.

Poor delintering and poor separation of hulls from the meats result in excessive loss of oil because of the high absorption capacity of these substances.

Poor rolling or flaking makes it impossible to press out the oil in the hydraulic press.

However, the most serious source of oil loss is the result of poor cooking and this in turn results from inadequate equipment. Most of the cotton-oil mills in Venezuela are equipped with only single-stack cookers or kettles instead of three- to six-stack cookers, which are required for proper cooking.[1] It is recommended that all cottonseed-oil mills install at least four-stack cookers equipped with quick-opening gates or valves so they can be operated as either batch or continuous cookers. The use of single-stack cookers is a false economy; it results in oil losses amounting annually to many times the cost of installing multiple-stack cookers.

In general, the hydraulic presses were observed to be in relatively good condition despite their age and rather hard usage. Some of them, however, were in a bad state of repair and should have been discarded long ago.

No cake strippers or cake trimmers were observed in any of the mills operating box-type hydraulic presses. The failure to trim the cakes from this type of pressing operation is the cause of appreciable loss of oil.

The operation of the press room in a modern cotton-oil mill is no longer an art but a science. The successful operation of the press room formerly depended upon the acquired skill of the meal cook, who decided by the "feel" and "smell" whether the meats (kernels) were properly cooked and ready for pressing. Today, automatic control of the moisture, checked by analyses of meats in the cooker, automatic control of temperature, etc., have largely replaced the sensory operation of the meal cook. There have been resultant increases in both the volume and quality of oil produced.

The combined capacity of crude-oil mills in Venezuela is greatly in excess of the volume of oil-bearing materials available for processing. As a result, a large part of the existing capacity remains idle a considerable portion of each year. Furthermore, much of this equipment is obsolete and highly inefficient. Some inefficiency will soon be overcome by the installation of new equipment. Based on the present volume of oil-bearing materials being processed, several hundred additional tons of oil a year could be recovered by more efficient processing.

It would be preferable to concentrate the production of crude oil in a few large, well-equipped, and strategically located oilmills rather than in the present 26 scattered mills. As a matter of fact, the present total production of crude oil in Venezuela would represent only a few weeks operation in a moderate-sized oilmill. The relatively large number of small and scattered mills necessarily results in high production costs through multiplied managements, idle equipment, inefficient operation, lack of adequate technical control, and many other factors. The fat-and-oil economy of Venezuela could be materially improved by a judicious merger of existing concerns, abandonment of the smaller and less efficient plants, and the centralization of all crude milling operations in a few modern large-capacity plants.

Cottonseed is, of all of the common oil-bearing materials, the most difficult and most ex-

pensive to process. When processing is done with obsolete and inadequate equipment, without adequate chemical control and proper instrumentation, the difficulties are multiplied, efficiency is reduced, and the cost of the finished product is increased. In a highly competitive economic system, inefficiency cannot continue very long. It can persist only when all losses from inefficient and costly operation can be passed on to the consumer. Inefficient conditions are fostered by world shortages and high protective tariffs on finished products.

Refineries and Shortening Plants

The vegetable-oil refineries of Venezuela, like the crude-oil mills, vary in capacity, type of equipment, and relative efficiency. Refining operations in all the plants visited were carried out in open kettles, a process now practically obsolete in the United States.[2] Some of the refining kettles and other equipment are of exceedingly small capacity. The smallest kettle observed was stated to have a capacity of about 1,000 liters and the largest a capacity of 8,500 kilograms, compared with more or less standard kettles of 30,000 liters (8,000 gallons) used in the United States before conversion to continuous refining. The installation of one of the modern continuous refining methods would appreciably increase the yield of refined oil from the same volume of crude oil now being processed by the kettle method.

Several of the refineries visited were, with the exception of the use of refining kettles, well equipped and relatively modern. Nearly all of the larger refineries dry and bleach the alkali-refined oil under vacuum (Figure 47). Ordinarily, only fuller's earth is used for bleaching but some plants use activated earth and several use a mixture of earth and carbon. In general, filter aids are not employed. Moreover, where the oil is to be used for cooking and for salads drastic bleaching is not essential. One firm stated that it could produce a shortening similar in color to the best grades of white shortening manufactured in the United States, but such a product is not acceptable to the majority of consumers, who prefer a fat somewhat more yellowish or grayish in color, similar to the lard they are accustomed to using.

No winterizing equipment was observed in any plant and it is assumed that winterized salad and mayonnaise oils are not yet in great demand because of the prevailing high temperatures and the small number of household refrigerators.

Figure 47. Left to right, refining kettle, vacuum-drying and bleaching kettle, and deodorizer in a Venezuelan vegetable-oil refinery.

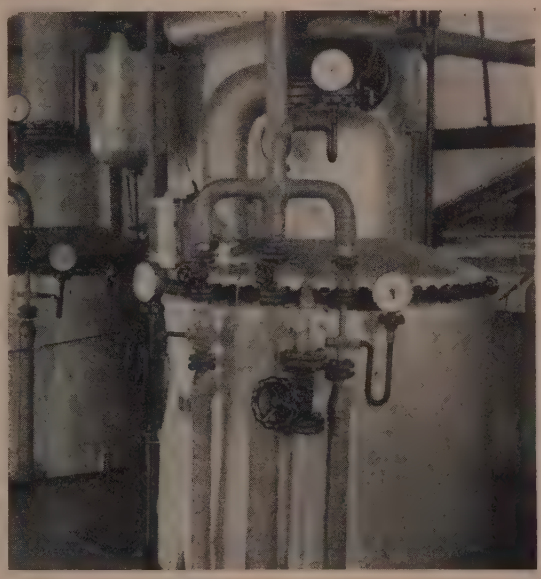


Figure 48. Modern vacuum deodorizers in a Venezuelan vegetable-oil refinery.

All types of oils are generally deodorized (Figure 48) at lower temperatures and higher pressures than in the United States. Deodorization temperatures generally vary from 170° to 190° C. (335° to 375° F.) compared to tem-

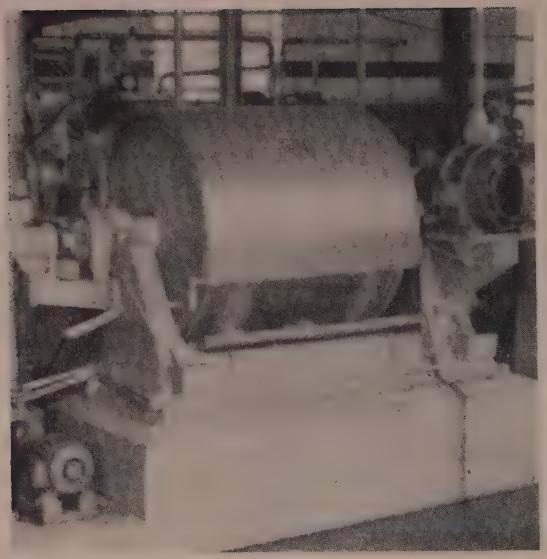


Figure 49. Old-type chill roll for crystallizing fat to produce shortening.

Figure 50. New Votator used in crystallizing fat to produce shortening. Same plant as Figure 49.

peratures of 225° to 250° C. (425° to 475° F.), which are generally considered essential to rapid and complete deodorization [3] in the United States. These lower temperatures probably represent the highest safe working temperatures attainable with existing equipment.

Some practices were observed that would not be tolerated in a modern refinery. For example air is used to agitate the crude oil during addition of alkali in one plant. The oil is saturated with air (oxygen), and, on heating, the oil is oxidized, which lowers the quality of the product. In several plants brass pipe and cocks were observed, especially for handling finished oil. Copper is known to be a powerful pro-oxidant for vegetable oils, even in concentrations of one-half part per million. Finished oil that comes in contact with brass or copper equipment rapidly oxidizes and becomes rancid.

Several of the refineries visited have units for the manufacture of shortening. Shortening is produced by melting and mixing coconut oil and highly hydrogenated oil (140° F. stearine) with liquid oils and solidifying the mixture on a chill roll. Two plants were operating or installing Votators when they were visited.

In general, refinery and shortening-production equipment is not in excess of required needs. However, some refinery capacity was idle because of lack of crude oil and one plant was refining imported crude oil. Most of the idle refinery capacity has small, inefficient, and obsolete equipment.

Refinery operations, even more than crude oil-milling, are more economically performed on a large scale, all the more reason to concentrate refinery operations in a few large plants. And, replacement of the obsolete kettle process by continuous (centrifugal) refining would appreciably increase the yield of refined oils.

No hydrogenated fats are produced in Venezuela but there has been considerable discussion on introduction of the hydrogenation process. This process cannot be operated economically on a small scale and no single concern could justifiably install it for its sole use. However, a single plant could supply the entire Venezuelan need for all types of hydrogenated fats. At present, only 140° F. stearine is in appreciable demand for use in making shortening. However, if a hydrogenation plant were erected it could produce other types of hardened oils, including so-called all-hydrogenated shortening.

Although shortening is manufactured in several plants (Figure 49), and in two of those visited by the modern Votator process (Figure 50), no corresponding production of margarine was observed. Manufacture of this product could augment the greatly deficient butter supply. The chief ingredients for producing margarine—skim milk, coconut and other oils—are available in Venezuela. Properly fortified with fat-soluble vitamins, margarine is equally as nutritious as butter and considerably cheaper.

Technical Control and Management

Only the largest oilmills and refineries maintain laboratories and exercise moderate chemical and technical control of their operations. But the equipment of the best of these laboratories is confined to the barest essentials. Facilities and personnel for research and product and process improvement are practically nonexistent even in the largest plants.

Most of the plants are operated by rule of thumb rather than by the application of up-to-date scientific and technical principles, so the efficiency of any operation or of any plant is generally unknown. Technically trained engineers and chemists are conspicuous by their absence. However, some of the plant superintendents are very capable.

Chemical analysis of all raw and finished products, maintenance of material balance records, installation of modern instrumentation, a desire to decrease unnecessary losses and to increase the quality of finished products would do much to increase the supply of fats, oils, and their derivatives, and would lower the consumer cost.

Concentration of crude milling and refinery operations in a smaller number of larger and more efficient plants would increase production while lowering unit costs of operation. Unfortunately, the high cost of transporting raw materials to a few strategically located plants and distribution of finished products to the centers of consumption might wipe out all of the economies effected by centralization.

Management in the largest and best-operated oilmills and refineries of Venezuela is cognizant of all these problems and difficulties and is planning to resolve them as rapidly as possible. With more modern and larger equipment, better chemical and technical control, higher over-all efficiency, and the diversification and improvement of products, these plants will have an economic advantage with which the smaller and less efficient plants cannot compete.

Several hundred additional tons of fats and oils could be provided annually in Venezuela simply by improving present crude-mill and refinery practices to decrease excessive losses.

LITERATURE CITED

[1] O. H. Alderks. "Cooking of Meats and Recovery of Oil," in *Cottonseed and Cottonseed Products, Their Chemistry and Chemical Technology,* edited by A. E. Bailey. New York: Interscience Publishers, Inc., 1948. P. 618.

[2] E. M. James. "Processing of Cottonseed Oil," in *Cottonseed and Cottonseed Products, Their Chemistry and Chemical Technology,* edited by A. E. Bailey. New York: Interscience Publishers, 1948. P. 692.

[3] A. E. Bailey. *Industrial Oil and Fat Products.* New York: Interscience Publishers, 1945. P. 539.

VIII General Considerations

Collection and Publication of Statistics

ONE of the principal obstacles confronting the Mission in obtaining an adequate understanding and quantitative evaluation of Venezuela's fat-and-oil economy was the lack of readily available and reliable statistics. This inadequacy has been recognized by many Venezuelan government officials and by many technical experts who have gone to Venezuela to make surveys, and to help solve various economic problems. The present Government is making efforts to improve its statistical service.

The Mission wishes to stress the very great importance of collecting and publishing in concise and readily available form all statistics pertaining to the various phases of Venezuela's fat-and-oil economy.

These data should include crop-production records of all annual oilseed crops and all perennial oil-bearing plants; receipts of all oil-bearing materials at processing plants; production of crude oil, oilseed cake, and such by-products as hulls, linters, etc.; receipts of crude oil at refineries; production of refined oil and soapstock; production of finished products such as salad and cooking oils, shortening, margarine, soap, etc.; imports and exports of all these commodities; domestic production of lard, tallow, and grease from all types of commercially slaughtered animals; imports and exports of animal fats; production, imports, and exports of fish and marine oils; production and imports of paints, varnishes, enamels, and other protective coatings; production and imports of prepared greases, detergents other than soap, etc.

It is further recommended that these statistics be published monthly in a special publication similar to the *Fats and Oils Situation* of the Bureau of Agricultural Economics, U. S. Department of Agriculture, and that they be summarized in an annual publication.

It is further recommended that, before instituting a system for the comprehensive collection of statistics, one or more Venezuelan statistical experts be sent to Washington to obtain detailed information from the Bureau of Agricultural Economics, U. S. Department of Agriculture; the Bureau of the Census, U. S. Department of Commerce; the Division of Economics, Marketing and Statistics and the Distribution Division, FAO, on the mechanics of collection, analysis, and publication of these statistics, and of financing such a publication service.

The Mission believes that a statistical service of this type can be of the greatest practical assistance to many government agencies, producers, processors, merchants, and consumers.

Crop-Production Loans

Because of the many hazards involved in making crop-production loans under conditions existing in Venezuela, the present system of making such loans should be revised. Instead of advancing a farmer the total sum required for producing a given oilseed crop, such as sesame, this sum should be divided into several payments to be made at various periods throughout the production season.

The requisite portion of the total loan should be made to enable the farmer to purchase seed and fertilizer, prepare and plant his land. After the plants come up, the fields should be inspected by a representative of the agency responsible for the loan, the extent of the area planted and its general appearance certified by the agent. Thereafter, another portion of the loan equivalent to the amount required for cultivation, spraying, irrigation, and other expenses should be advanced. The fields should be inspected at least once more during the growing season, preferably just before harvesting. The final portion of the loan to cover harvesting, marketing, etc., should then be made.

Under such a system of progressive farm loans, the danger of loss to the lending agency is reduced to a minimum. If the seed does not come up because of poor germination, bad land preparation, or other causes, no additional loan need be made unless reseeding is planned and feasible.

If during the growing season the crop is partly or completely destroyed by insect invasion, disease, drought, or other causes, the portion of the loan covering cost of harvesting and marketing can be proportionally reduced.

All field inspections should be made by trained agronomists or agricultural agents; the same inspector should not report on the same farm more than once in any one year. A limited number of agronomist-inspectors traveling from one area to

another would soon result in a well-trained inspection corps. This group could provide a great deal of information on Venezuelan farm conditions that would be invaluable in the solution of agricultural problems.

It is essential, however, that all inspections and proportional loans be made promptly. Otherwise the farmer may be unable to cultivate, irrigate, or harvest his crop.

Industrial Fats and Oils

This report is concerned primarily with edible fats and oils. However, appreciable quantities of these substances are consumed in inedible or industrial channels. Industrial fats and oils include tallows, greases, inedible coconut and other lauric-acid oils, used in the manufacture of soaps and detergents; linseed, tung, and dehydrated castor oil, used in the protective coating industry; coco butter, lanolin, castor oil, and others, used in the preparation of cosmetics, pharmaceuticals, etc. Practically all of these oils are imported to some extent.

In general, these oils are secondary in quantity and importance to the fat economy of Venezuela compared with the volume and importance of dietary fats. But they should not be entirely ignored on this account. It is recommended that properly qualified persons in Venezuela undertake an analysis of industrial fats similar to the foregoing analysis of dietary fats.

It is quite possible that part or all of these fats and oils could be produced in sufficient quantities to satisfy the domestic needs of Venezuela.

Fish and Marine Oils

Fish are an important item in the diet of many Venezuelans. According to various reports [1, 2, 3], about 20 percent of the population lives on fish from the sea, rivers, and lakes. Official reports indicated a production in 1940 of 7,681,000 kilograms of fresh and 6,242,000 kilograms of salt fish. These figures are considered to represent far less than half of the actual commercial catch, which is estimated at approximately 40,000,000 kilograms. Fish consumption is thought to be approximately 30 pounds per capita, or about the same as in the United States. Fish are normally rich in fat and the relatively high average consumption adds materially to the "invisible" fat supply in the Venezuelan diet.

Various recommendations have been made to improve and expand the fishing industry, and measures have been successfully undertaken in this direction. In view of Venezuela's favorable situation with respect to fishing resources, efforts should be directed toward the development of a fish-oil and fish-meal industry, either as a by-product of the edible fishing industry or by catching and processing inedible or less desirable species, or both.

Fish oil can be processed for use in the protective coating industry as a linseed oil extender or exported against imports of edible oils or oilseeds. Fish meal is an excellent source of protein concentrate, which is greatly needed by beef, dairy, and poultry producers. Both oil and meal can be recovered from the waste at existing fish-processing plants.

Interchangeability of Fats and Oils

In considering the expansion of production of oilseed crops it should be borne in mind that different oils have different uses and complete interchangeability is not possible, even in countries with maximum technological development. Interchangeability of fats is even more restricted in the absence of technical know-how and processing equipment to modify the natural fats for specific end-uses.

Fats and oils may be divided into three broad groups with respect to end-uses: (1) edible fats, (2) soap fats, and (3) drying oils. Edible fats can be further divided into (a) liquid oils and (b) plastic fats (butter, margarine, lard, and shortening).

Where hydrogenation facilities are available, liquid oils can be hardened to produce plastic fats. Where dehydration facilities are available, nondrying castor oil can be converted into a product suitable for the manufacture of varnishes and enamels. Some oils, like coconut, palm kernel, *corozo*, etc., can be used both as an edible oil and as a soap oil. On the other hand, palm oil is a good soap oil but a poor edible oil, even after hydrogenation.

In order to manufacture a finished product, such as shortening, margarine, or soap, the use of more than one kind of oil or fat is required. Therefore, in deciding what oilseed or oil-bearing plant is to be increased, consideration should be given to the need for its oil compared with the need for other types. If this is not done, it may be found that there is a surplus of a given fat or oil and that there is still a deficit in an equally necessary oil of another type.

LITERATURE CITED

[1] *Revista del Ministerio de Fomento,* 1939.

[2] Servicio de Pesquería, Ministerio de Agricultura y Cría.

[3] *Report of Higgins Engineers to the President of Venezuela.* New Orleans: Higgins Industries, Inc.

Acknowledgments

CITIZENS and officials of Venezuela were uniformly cordial and helpful to members of the Mission. Assistance rendered and information supplied were of considerable importance to the survey and are gratefully acknowledged.

Although it is impractical to name everyone who contributed to the work of the Mission, it is desired especially to express sincere thanks and appreciation to Dr. Eduardo Calcaño, Director of the Division of National Cartography, and to his assistants, Medina and Madison, for their excellent co-operation, courtesy, and competent assistance in making the aerial surveys; to Major Guerrero of the Venezuelan Army Air Corps for placing a well-equipped airplane at the disposal of the Mission to be used in aerial reconnaissance and photographic work; to Lieutenants Martín Parada and Carlos Maldonado and Technical Sergeants Robinson Torres, Gonzalo Baquero, and J. R. Quintero for the capable handling of the plane; and to Dr. Eric Manelski and Juan Zambrano Perozo, Oilseed Branch, Venezuelan Development Corporation, for their sustained interest and co-operation during the work of the Mission.

Special thanks and acknowledgment are extended to James H. Kempton, Agricultural Attaché of the U. S. Embassy, for the assistance and information he provided all members of the Mission, and to Dr. D. G. Langham, Genetics Branch, Ministry of Agriculture and Animal Husbandry, who was most helpful during the survey of annual oilseed crops and in organizing and conducting the survey in Portuguesa.

The Mission also wishes to acknowledge the interest and assistance of the following:

In Caracas and Vicinity:

Alejandro Oropeza Castillo
President, Venezuelan Development Corporation

Andrés Germán Otero
Director, Venezuelan Development Corporation

Héctor Santaella
Assistant Manager,
Venezuelan Development Corporation

Ricardo de Sola,
Engineer,
Venezuelan Development Corporation

B. Milá de la Roca, Jr.
Chemist, National Laboratory (*Laboratorio Nacional*)
Ministry of Development

Ricardo Montilla
Ministry of Agriculture and Animal Husbandry

Mauricio Báez
Director, Agriculture Division
Ministry of Agriculture and Animal Husbandry

Emilio Condejahn
Director, Agricultural Economics Division
Ministry of Agriculture and Animal Husbandry

Carlos Eduardo Velezeo
Agricultural Economics Division
Ministry of Agriculture and Animal Husbandry

Oscar Grünwald
Chemistry Branch
Ministry of Agriculture and Animal Husbandry

Francisco Tamayo
Institute of Experimental Agriculture and Zootechnology
Ministry of Agriculture and Animal Husbandry

Luis Schnee
Institute of Experimental Agriculture and Zootechnology
Ministry of Agriculture and Animal Husbandry

Werner Jaffé
Institute of Experimental Agriculture and Zootechnology
Ministry of Agriculture and Animal Husbandry

Robert H. Tschudy, Botanist
Creole Petroleum Corp.

A. Benazzi

Miss Alice James, Technical Librarian
Creole Petroleum Corp.

Pedro Augustín Dupouy
Secretary, Venezuelan Banana Co.

Juan Francisco Stolk
Cipreses Irrigation Co.

Ernest Korber, Gerard Jansen, and James Valencia
Industrial Fat Products Co.

In Maracay and Vicinity:

Rafael Silva Guillén
Agronomy Branch
Institute of Experimental Agriculture
Ministry of Agriculture and Animal Husbandry

Agustín Dupuy
Institute of Experimental Agriculture
Ministry of Agriculture and Animal Husbandry

Samuel S. Strebin
Soils Branch
Institute of Experimental Agriculture
Ministry of Agriculture and Animal Husbandry

Clifford H. Meredith
Pathology Branch (*Departamento de Patología*)
Institute of Experimental Agriculture
Ministry of Agriculure and Animal Husbandry

Juan de Guruceaga
Maracay Oilmill

In Valencia:

Ricardo Degwitz, Director
FACEGRA Co.

Henrique F. Heemsen
Las Llaves Co.

Ernesto Stelling, Owner
Pérez, Aikman & Co.

In Puerto Cabello:

Alfredo Capriles
Las Llaves Co.

Marcel Monfils, Manager
Venezuelan Banana Co.

François Moens
Venezuelan Banana Co.

Oscar Pérez Mena
Pérez Mena Co.

In Agua Blanca:

Roberto V. Peña, Manager
Rockefeller Plantation

In Coro and Vicinity:

Edwin Lebrun
Pan-American Hotel

Gustavo de Lima
Chief, Falcón State Experimental Farm

Angel M. Yánez and I. Lansberg

The Mission also wishes to express its appreciation to Mrs. Evald L. Skau, librarian; Clifford H. Billett, photographer; and Miss Leah Katz, draftsman, all of the Southern Regional Research Laboratory, New Orleans, U. S. A., for their advice and assistance in the preparation of this report.

SALES AGENTS FOR FAO PUBLICATIONS

Australia

H. A. Goddard Pty. Ltd.
255a George Street
Sydney

Canada

The Ryerson Press
299 Queen Street West
Toronto 2, Ontario

China

The Commercial Press Ltd.
211, Honan Road
Shanghai

Colombia

Agricultura Tropical
Avenida Jiménez, Número 8-74
Bogotá

Costa Rica

Trejos Hermanos
San José

Cuba

René de Smedt
La Casa Belga
O'Reilly 455
Havana

Czechoslovakia

F. Topic
Narodni 9
Prague 1

Denmark

Ejnar Munksgaard
Nörregade 6
Copenhagen

El Salvador

Librería Navas
Avenida Sur 37
San Salvador

Finland

Akateeminen Kirjakauppa
2 Keskaskatu
Helsinki

France

Les Editions A. Pedone
13, rue Soufflot
Paris 5e

Hungary

Grill's Bookshop
R. Gergely Ltd.
Dorottya Utca 2
Budapest V

Latin America

(except Colombia, Costa Rica, Cuba, El Salvador, and Mexico)
International Documents Service
Columbia University Press
2960 Broadway
New York 27, N. Y.

Lebanon

Librairie Universelle
Avenue des Français
P. O. Box 1191
Beirut

Mexico

Manuel Gómez
Pezuela e Hijo
Danceles 12
Mexico, D. F.

Netherlands

N. V. Martinus Nijhoff
Lange Voorhout 9
The Hague

Norway

Messers Johan Grundt Tanum
Kr. Augustagt 7a
Oslo

Pakistan

Farcos' Publications
2, Inglis Road
Dacca P. N. 13
Ramna, East Pakistan

Switzerland

Librairie Payot, S.A.
Lausanne

Hans Raunhardt
Kirchgasse 17
Zurich 1

Syria

Librairie Universelle
Avenue des Français
P. O. Box 1191
Beirut, Lebanon

United Kingdom

H. M. Stationery Office
429 Oxford Street
London W. 1, England

United States

International Documents Service
Columbia University Press
2960 Broadway
New York 27, N. Y.

United Nations Bookstore
Lake Success, N. Y.

(locally in Washington, D. C.)

FAO Documents Sales Service
1201 Connecticut Avenue, N.W.
Washington 6, D. C.

Yugoslavia

Drzavno Predusece
Yugoslavenska Knjiga
Marsala Tita 23/11
Belgrade

Requests from countries where sales agents have not yet been appointed may be sent to:

FAO Documents Sales Service
1201 Connecticut Avenue, N.W.
Washington 6, D. C.

Price $1.00